The Baltimore Rowhouse: An Abbreviated Guide to Greening the Iconic Brick Rowhome

By Janice Romanosky and Prescott Gaylord
The Baltimore Rowhouse: An Abbreviated Guide to Greening the Iconic Brick Rowhome

By Janice Romanosky and Prescott Gaylord

ABOUT THE AUTHORS

Janice Romanosky is a RESNET HERS Rater and LEED/NGBS Green Rater. Her company, Pando Alliance LLC, was formed with the mission of providing quality, 3rd party rating and certification services to construction and design professionals throughout the region. Ms. Romanosky provided Energy Star consulting and rating services to the builders and developers who participated in the Green Rowhome Challenge. In doing so, she has witnessed a variety of approaches to insulation, air sealing and mechanical systems. Throughout her career, Ms. Romanosky has actively supported green building education, advocacy and research.

Prescott Gaylord is a green builder and green building consultant in the Baltimore area. He provides sustainable construction advice for solar thermal installations, deep energy retrofits, zero net energy buildings, Living Buildings, and Passive House level design and construction projects.

Mr. Gaylord was co-founder of Baltimore Green Construction and general manager of the Entellis Collaborative which separately helped with or built Baltimore’s first LEED Platinum House, Maryland’s first LEED Platinum Homes community, Maryland’s first net zero state building, and Baltimore’s first LEED Gold commercial building. He has helped launch the region’s first net zero energy affordable housing complex, and is working on a Living Building in Baltimore. Mr. Prescott is the Chair of the Maryland Governor’s Green Building Council, and has served on the boards of the USGBC® Maryland and the Baltimore Center for Green Careers.

ABOUT ENTERPRISE COMMUNITY PARTNERS

Enterprise works with partners nationwide to build opportunity. We create and advocate for affordable homes in thriving communities linked to jobs, good schools, health care and transportation. We lend funds, finance development and manage and build affordable housing, while shaping new strategies, solutions and policy. Over more than 30 years, Enterprise has created nearly 320,000 homes, invested nearly $16 billion and touched millions of lives. Join us at www.EnterpriseCommunity.org.

Disclaimer: The information in this document is provided to you gratuitously and there is no agreement or understanding between you and the authors and Enterprise. This document is meant only as a guide. The purpose of this document is to provide guidance on rehabilitation best practices for residential rowhouses. Information given in this document shall in no event be regarded as a guarantee of any particular outcome, results, conditions or characteristics. The authors and Enterprise makes absolutely no representations, warranties, promises or guarantees with respect to the contents of this document, express or implied, including, but not limited to warranty of merchantability or fitness for a particular purpose. The authors and Enterprise assume no liability or responsibility for the accuracy, completeness or usefulness of any information, equipment, apparatus, product, process or other item provided in this document. References in this document to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply are commendation or endorsement by the authors and Enterprise.

Please send questions regarding usage of this information to:
Jessica Sorrell, Program Director
Enterprise Community Partners, Inc. | 10 G Street, NE, Suite 580 | Washington, DC 20002
202.649.3923 | jsorrell@enterprisecommunity.org

Copyright © 2014, Enterprise Community Partners, Inc. All rights reserved.
Photos on cover and page 2: Harry Connolly
All other photos are courtesy of Janice Romanosky.
# CONTENTS

**Introduction** 4  
**Context of the Market** 5  
**Moisture, Building Science and the False Comfort of a Standard** 6  
**Envelope Decisions** 7  
  - About Masonry Walls 7  
  - Air Sealing Strategies in Walls 9  
  - Insulation Strategies in Walls 10  
  - About Ceilings and Attics 11  
  - Insulation Strategies in Ceilings 12  
  - About Basements 13  
**Mechanical Decisions** 14  
  - Ventilation 14  
  - Whole House Ventilation Strategies 15  
  - Importance of Spot Ventilation 15  
  - Space Heating and Cooling 16  
  - Water Heating 16  
**Other Decisions** 17  
  - Lighting 17  
  - Appliances 17  
  - Water Efficiency 17  
  - Healthy Materials 18  
  - Storm Water Management 18  
**The Future of the Green Rowhome** 19  
**Glossary** 21
The intent of this guide is to answer the question: What key concepts are indispensable for greening a Baltimore rowhouse rehab?

This guide includes discussions on energy and water efficiency, indoor air quality, and materials reuse. It was produced for the benefit of affordable housing developers, contractors, financiers, designers, and communities who are collectively working toward the goal of providing healthier and more efficient homes. Because the audience is broad, the concepts presented herein are necessarily an overview of what matters and why.

This guide is the product of the Enterprise Green Rowhome Challenge, a study in which a group of Baltimore area affordable housing developers strove to meet the green requirements placed upon them by a U.S. Department of Housing and Urban Development (HUD) Neighborhood Stabilization Program (NSP) grant in 2009. Specifically, developers were required to commit to ENERGY STAR 2.0 certification and a green standard of their choosing. In most cases, developers elected to follow the 2011 Enterprise Green Communities (EGC) Criteria. The Rowhome Challenge offered developers access to free rating services and more importantly, the necessary expertise to help them understand the requirements of these unfamiliar programs. This was a powerful incentive for developers to commit the necessary time and resources to learn how to incorporate green and energy efficient features into their homes.
CONTEXT OF THE MARKET

THE IMPACT OF OPERATING COSTS
Baltimore City has increased water and sewer fees by more than 50% since 2008, and continues to impose double digit increases annually as the needs of a crumbling infrastructure place increasingly heavy burdens on this cash-strapped city. Likewise, local utility rates have continued to trend upward. Attention to energy and water conservation strategies during design and construction are critical to maintaining affordability in home ownership.

THE IMPACT OF CODE
Although the Rowhome Challenge wrapped up only a few years ago, seismic changes have occurred in energy codes since that time. The State of Maryland adopted for all jurisdictions – including Baltimore City, the 2012 International Energy Conservation Code (2012 IECC) and with it, mandatory building tightness standards that must be proven by performance testing. So great was this change that many parts of the energy code now surpass the performance standards established by ENERGY STAR 3.0 and by reference, requirements of the 2011 EGC Criteria. This aggressive new standard of air tightness presents complex challenges to rowhome rehabbers as they must find ways to maintain affordability and building durability, even while meeting the demands of more rigorous codes.

More simply, some of the guidance dispensed several years ago during the Rowhome Challenge construction period is today no longer applicable to what owners and project teams must grapple with in the field. Most significant is the relationship between building tightness and moisture management.
Today’s builder could reasonably assume that as long as they adhere to the codes, or even a green standard, the end result will be a durable, energy efficient home.

Unfortunately, codes and standards, while flexible enough to be satisfied with a variety of materials and methods, can still create a moisture risk in the finished product.

For example, the 2012 IECC mandates how tight a building must be, but is silent on materials which, although compliant, can trap moisture in walls. While the International Residential Code (IRC) prescribes measures related to moisture management, neither of these codes addresses the unique challenges of building to code in a mixed humid climate like Baltimore. Herein lies the problem: Materials, assemblies and strategies that work well in one part of the country can be troublesome in Baltimore’s mixed humid climate zone, and even more so when installed in a gutted, masonry shell.

The problem is essentially threefold:

1. There is a false comfort in following a code or standard, especially those that include provisions for moisture control.

2. Rapidly evolving standards do not take into account the drastic differences in climates and moisture cycles in different parts of the country.

3. Following such codes and standards without further regard for this unique climate zone may trap moisture in assemblies and create conditions conducive to mold.

It is not enough to follow codes and standards without also understanding how various measures and systems interact with each other. This “House as a System” perspective is critical for understanding how code-compliant choices in materials, assemblies and strategies can impact the long term durability of the home, for better or worse. This report discusses many strategies and measures. While all may be code compliant, not all are recommended.

Throughout this report, the ⚠️ symbol indicates an identified risk. Either that measure alone, or when coupled with another strategy or existing condition, heightens the risk of moisture-related damage, poor indoor air quality or comfort complaints.
S

imply stated, the function of the building envelope is to separate the inside from the outside. To do this effectively, the envelope components must work together to hold temperature extremes, air infiltration, moisture and pollutants at bay. A few key concepts to keep in mind:

- Bulk water intrusion must be stopped absolutely at the outside layer.
- Air infiltration must be substantially eliminated at the outside layer.
- The air barrier must be in full contact with the thermal barrier (insulation).
- The air and thermal barrier are sometimes one material, i.e. spray foam.
- Batt insulation and other fibrous materials are not air barriers. To be effective, these materials must be enclosed on all sides.

Following are discussions of key envelope components and assemblies, and options for constructing them.

ABOUT MASONRY WALLS – ABOVE GRADE

This discussion will be limited to above grade, masonry walls, both exterior and party. Below grade walls will be discussed in the section about basements on page 14.

While the concepts are simple, insulated masonry walls can be complex assemblies, and successful execution requires some thoughtful planning of the components and details. Constructing an effective wall assembly requires the following:

Step 1: Plug the holes. This is the first and only real defense against bulk water intrusion. Replace damaged or missing bricks, including at window and door openings. Fill and point all holes and gaps from inside and outside – even small ones, in both exterior and party walls, and around openings. Nothing else will matter if this most basic requirement is not handled with the utmost attention to detail.
Step 2: Apply an air barrier.

- An air barrier is to the building what a tightly woven, outer shell is to a ski jacket. Both are more effective when there are no breaks or openings. To ensure a continuous, top to bottom air seal, remove a strip of subfloor at the perimeter to allow easier access for sealing between the band and the brick.

- If using spray foam, the air barrier and the insulation may be provided with a single product, depending on depth of application.

- If using a fibrous insulation such as blown fiberglass or cellulose, it will be necessary to apply a separate air barrier before insulating.

- For walls in very good condition, whether existing or repaired, a fluid-applied, elastomeric sealant can be effective as a standalone product.

- For irregular walls in poor condition, parge the entire wall surface with a coating of lime-based mortar, including around joist pockets. Lime-based mortar is recommended over more common cement parging because it is less likely to shrink or crack over time.

- For heavily damaged walls, it may be necessary to apply a coat of sealant over the parging.

⚠️ Relying solely on the drywall to serve as the primary air barrier might enable the home to pass the code-mandated blower door test, but may not prevent moisture from invading the wall cavities.

Step 3: Frame the walls. Stand the framing off the walls (2” gap recommended). This allows insulation to fill in behind the studs to create a continuous layer. Use advanced framing techniques to allow for insulated corners, wall intersections and headers. Put no more wood in the wall than necessary for structural purposes.

Step 4: Install windows. Seal to openings with caulk or foam. Do not attempt to seal with fiberglass chinking. Flash according to details provided in Department of Energy (DOE) Building America’s “Measure Guideline: Internal Insulation of Masonry Walls,” [www.nrel.gov/docs/fy12osti/54163.pdf](http://www.nrel.gov/docs/fy12osti/54163.pdf)

Install fixed windows in locations where operation is impractical and unlikely. Consider casement style windows for maximum air tightness. Tight window assemblies are helpful for meeting code required air tightness standards.

The state of the market for efficient windows has improved considerably. Higher performing windows are now price competitively with typical, code-minimum windows. The payback on replacement windows can be three decades or more, so choosing the best performing window within budget – at the time of renovation – is money well spent.
**Step 5:** Insulate the walls. For a foam-free approach, dense pack the walls with fiberglass or cellulose. Dense pack is defined as 3.5 lb/cf, so a calculation of the wall volume, including the space behind the studs, will be required in order to determine the number bags required to achieve this density.

If insulating with foam, a water-blown, open cell formula is recommended. Because it is more elastic than closed cell foam, this material can move with the structure of the home as brick and framing expand and contract with the seasons. In addition, open cell foam is also more vapor open, which allows for better drying of the wall assembly. The 2012 IECC allows for as little as an R-value of R-10 in a masonry wall assembly (approximately 3” if insulating with open cell foam). However, in this climate zone, filling the wall cavity is strongly recommended to keep the wall warm enough to prevent condensation of water vapor within the wall cavity.

**Step 6:** Install drywall. Seal around duct boots, returns and all other penetrations.

Following are tables showing the various options for insulating and air sealing wall assemblies. *While all are code-compliant, not all are recommended.*

### Air Sealing Strategies in Walls

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>⚠️“Traditional” air seal practices.</strong> (Relies on drywall as primary air barrier) Repair larger holes in masonry walls, then caulk around doors, windows and holes in the drywall. <strong>NOT RECOMMENDED</strong> in this climate because moisture can become trapped in walls and promote mold growth.</td>
<td>Least expensive. Skilled labor not required.</td>
<td>Will fail 2012 IECC air tightness requirements. High air infiltration through unsealed brick allows moisture into walls. Does not contribute to R-value of assembly.</td>
</tr>
<tr>
<td><strong>Lime-based parg coat over entire wall surface – integrated with mortar repoint – including party wall.</strong> Lime mortar is typically not available as a pre-mixed product. Its components must be mixed on site.</td>
<td>Much more effective than typical caulk and foam. When properly applied, can achieve 2012 IECC requirements for air tightness and beyond. Vapor open assembly – good for moisture management. Non-toxic, unlike foams.</td>
<td>Does not contribute to R-value to assembly. Some reliance on skilled labor, such as mason or someone who has re-pointed.</td>
</tr>
<tr>
<td><strong>⚠️Closed cell foam, continuous 1.5” application over all wall surfaces, including party.</strong> This product created a vapor barrier. To allow for proper drying, no more than one vapor barrier should be present in the assembly. See Cons.</td>
<td>Reliable air seal. Meets 2012 IECC insulation requirements for mass wall construction. Somewhat reliant on skilled labor. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Shrinks if improperly mixed, so touchup may be required. Seasonal shrinkage of framing can break the air seal. Hazardous fumes during application. If combined with other vapor barriers such as kraft-faced batt or vinyl wallpaper, assembly may trap moisture due to inability to dry properly.</td>
</tr>
</tbody>
</table>
Air Sealing Strategies in Walls (continued)

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open cell foam, continuous 5.5” application over all walls, including party.</td>
<td>Reliable air seal. Exceeds 2012 IECC insulation requirements for mass wall construction. Somewhat reliant on skilled labor. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Shrink if improperly mixed, so touchup may be required. Hazardous during application. May not allow sufficient drying.</td>
</tr>
<tr>
<td>Smart membranes. More sophisticated approaches such as Passive House design incorporate vapor open membranes within wall and ceiling assemblies.</td>
<td>Vapor permeability prevents moisture from being trapped within wall assemblies.</td>
<td>Attached with specialty tapes. Taping technique is not a common skill, so training is required.</td>
</tr>
<tr>
<td>Fluid applied air barriers.</td>
<td>Very reliable air seal when applied over walls in good condition, or over parging.</td>
<td>Requires a two-step process to first fill large holes and gaps with parging.</td>
</tr>
</tbody>
</table>

For more information about airsealing brick rowhomes: [www.jlconline.com/energy-efficiency/old-school-meets-high-tech--air-sealing-a-brick-rowhouse_o.aspx](http://www.jlconline.com/energy-efficiency/old-school-meets-high-tech--air-sealing-a-brick-rowhouse_o.aspx)


Insulation Strategies in Walls

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Firebrick batts</strong>. When installed over a thin coat of closed cell foam, this technique is known as “flash and batt.” NOT RECOMMENDED unless installed as flash and batt, or in a cavity wall that has been 100% airsealed with parging or other sealants such as fluid-applied air barrier. If using flash and batt system, do not use kraft-faced batts.</td>
<td>Least expensive. 2012 IECC does not require quality installation, so skilled labor is not required.</td>
<td>High permeability of material and typical installation renders batts ineffective in fulfilling intended purpose. Can trap dirt and microbes which provide food for mold.</td>
</tr>
<tr>
<td>Blown-in Fiberglass. A stapled up netting or membrane behind which fiberglass is blown to densely fill cavity.</td>
<td>Loose fill conforms to rough, uneven surfaces, and can fill in gaps behind framing to achieve a continuous layer.</td>
<td>Product can settle in walls, leaving uninsulated gaps and voids if not installed properly.</td>
</tr>
<tr>
<td>Blown-in Cellulose. A stapled up netting or membrane behind which treated cellulose is blown to densely fill cavity.</td>
<td>Loose fill conforms to rough, uneven surfaces, and can fill in gaps behind framing to achieve a continuous layer. Can act as a bladder for minor water seepage and allow for gradual drying without major wetting of other wall components.</td>
<td>Product can settle in walls, leaving uninsulated gaps and voids if not installed properly. Can mask major leaks that would otherwise be identified earlier.</td>
</tr>
</tbody>
</table>
Insulation Strategies in Walls (continued)

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>⚠️ Closed cell spray foam, 1.5” continuous application behind framing.</strong> This product created a vapor barrier. To allow for proper drying, no more than one vapor barrier should be present in the assembly. If combining with batt, use only unfaced batts. See Cons.</td>
<td>Meets 2012 IECC insulation requirements for mass wall construction. Somewhat reliant on skilled labor. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Shrinks if improperly mixed, so touchup may be required. Seasonal shrinkage of framing can break the air seal. Hazardous fumes during application. If combined with other vapor barriers such as kraft-faced batt or vinyl wallpaper, assembly may trap moisture due to inability to dry properly.</td>
</tr>
<tr>
<td><strong>Open cell spray foam, 5.5” applied within and behind cavity framing.</strong></td>
<td>Exceeds 2012 IECC insulation requirements for mass wall construction. Somewhat reliant on skilled labor. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Shrinks if improperly mixed, so touchup may be required. Hazardous during application. May not allow sufficient drying.</td>
</tr>
<tr>
<td><strong>⚠️ R-10 rigid foam panels.</strong> This product created a vapor barrier. To allow for proper drying, no more than one vapor barrier should be present in the assembly. See Cons.</td>
<td>Meets 2012 IECC insulation requirements for mass wall construction.</td>
<td>Highly reliant on skilled labor in order to also achieve 2012 IECC requirements for air tightness. May not allow for sufficient drying.</td>
</tr>
</tbody>
</table>

For more information about foam-free, exterior walls in rowhouse rehabs: [www.jiconline.com/insulation/details-for-foam-free-superinsulated-construction_o.aspx](http://www.jiconline.com/insulation/details-for-foam-free-superinsulated-construction_o.aspx)

**ABOUT CEILINGS AND ATTICS**

Ceilings can be insulated in one of two ways: at the roofline (sometimes called encapsulated or sealed attics), or at the attic floor (a ventilated attic).

**Sealed Attics**

Where ductwork or HVAC (heating, ventilation, and air conditioning) systems are present in the attic, or if access is desired for other reasons, the attic should be sealed and insulated at the roofline with open cell spray foam. Other cases for encapsulated attics include complex ceiling or roof geometry, such as dropped or tray ceilings, mansard roofs and dormers, all of which create small knee walls that require special treatment when the attic is insulated at the floor. If encapsulating, all walls above the ceiling plane, including party walls, must be air sealed and insulated as exterior walls. Insulation should be sprayed continuously to completely seal the roof/wall intersection, and then continue down the walls, past the top floor ceiling.
### Insulation Strategies in Ceilings

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fiberglass batts</strong>. Very difficult to install in a manner that allows full contact with drywall ceiling. NOT RECOMMENDED.</td>
<td>Least expensive. 2012 IECC does not require quality installation, so skilled labor is not required.</td>
<td>High permeability of material and typically poor installation renders batts ineffective in fulfilling intended purpose. Can trap dirt and microbes which provide food for mold.</td>
</tr>
<tr>
<td><strong>Blown Fiberglass</strong>. Can be blown over ceiling drywall through hatch, or stapled up netting through holes.</td>
<td>Loose fill conforms around uneven surfaces to achieve a more continuous layer. Bulk water intrusion may be more readily detected than with cellulose.</td>
<td>Does not hold water from bulk leaks. Water may settle on framing or drywall and establish conditions conducive to mold.</td>
</tr>
<tr>
<td><strong>Blown Cellulose</strong>. Can be blown over ceiling drywall through hatch, or stapled up netting through holes.</td>
<td>Loose fill conforms around uneven surfaces, and can fill in gaps behind framing to achieve a continuous layer. Can act as a bladder for water intrusion and allow for gradual drying without major wetting of other components.</td>
<td>Absorptive capacity may conceal larger bulk water leaks until mold is established.</td>
</tr>
<tr>
<td><strong>Closed cell spray foam, 7” application to underside of roof deck.</strong></td>
<td>Meets 2012 IECC ceiling insulation requirements. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Somewhat reliant on skilled labor. Shrinks if improperly mixed; touch up may be required. Seasonal shrinkage of framing can break seal. Hazardous during application. Prohibitively expensive. All walls above ceiling drywall – including party walls, must be insulated and air sealed like all other exterior walls.</td>
</tr>
<tr>
<td><strong>Open cell spray foam, 14” application to underside of roof deck.</strong></td>
<td>Meets 2012 IECC ceiling insulation requirements. When properly applied, will achieve 2012 IECC requirements for air tightness.</td>
<td>Somewhat reliant on skilled labor. Shrinks if improperly mixed; touchup may be required. Hazardous during application. More expensive than fibrous products. All walls above ceiling drywall – including party walls, must be insulated and air sealed like all other exterior walls.</td>
</tr>
<tr>
<td><strong>R-38 continuous rigid foam panels at roof deck.</strong></td>
<td>Meets 2012 IECC ceiling insulation requirements.</td>
<td>All walls above ceiling drywall, including party walls, must be insulated and air sealed like all other exterior walls.</td>
</tr>
</tbody>
</table>

### Ventilated Attics

Do not install ductwork or mechanical systems in ventilated attics. Equipment installed in unconditioned spaces works harder to heat and cool the home, and can allow condensation on surfaces that can wet ceilings and grow mold. For even coverage that conforms well to framing, insulate attic floors with blown fiberglass or cellulose. For ceilings where no hatch is to be installed, blown insulation can be installed by attaching a supportive material such as netting or fabric to the ceiling joists, and then blowing material over the top of it.
ABOUT BASEMENTS
No rowhome rehab discussion would be complete without a review of basement options. Typically breezy, sometimes with through-the-wall views to into neighboring units or outdoors, and often with a history of water problems, the first step is to identify suitability for future uses.

Limited Use
If the basement ceiling is too low or the space is otherwise usable, the most economical solution is to carefully seal the floor cavity perimeter, including at party walls, taking extra care to seal around the joist pockets. Insulate the ceiling/floor assembly to full depth and enclose it tightly with a paperless or otherwise mold-resistant drywall such as one meeting ASTM (American Society for Testing and Materials) mold-resistant standards ASTM D3273. Install a weather-stripped, exterior door between the first floor and basement. Performed properly, these steps effectively separate the basement from the rest of the home.

Usable Space
If deemed potentially usable as finished living or utility area, the space should be actively heated and cooled. Aggressive steps should be taken to eliminate all sources of air and moisture intrusion, from bulk water at the foundation walls to water vapor rising through the slab.

If a new slab is indicated, install a polyethylene vapor barrier prior to pouring, just as for new construction. Otherwise, the existing slab should be sealed with an epoxy or liquid crystalline coating that penetrates the slab to form a vapor-impermeable barrier. If the basement has a walkout, remove a few feet of the slab at the walkout to install R-10 insulation at the edge, extending horizontally under the slab by 2 feet.

If there is evidence of a water problem, install a continuous and sealed drainage plane at exterior walls that terminates into a foundation drainage system. The drain should be sealed in such a manner that the moisture - whether water or vapor, never comes in contact with the basement air or surfaces. Sump pits should be sealed with a mechanically fastened cover. Seal the masonry walls completely, including around the joist pockets. Sealing complex geometry under entry steps require thought and creativity. It is much easier to seal the party wall before the stairs and ductwork are installed. Utility service should be mounted on a freestanding wall to allow for continuous air seal and insulation at the exterior walls. Insulate with a non-fibrous insulation such as spray foam or rigid foam panels, and enclose the assembly with a mold-resistant product.
MECHANICAL DECISIONS

Decisions related to heating, cooling, and ventilation should be made in conjunction with the overall design of the home, not as an afterthought. Since mechanical systems eventually fail, and the users may not replace in kind, it is best to invest more in permanent envelope measures than in HVAC systems. When placed in ventilated attics or unconditioned basements, HVAC systems and water heaters must work much harder and are less efficient than when installed within the home’s thermal boundary. As such, the home design should allow for placement of these mechanical systems within conditioned space. In fact, the 2012 IECC now requires a stringent performance test for duct systems with any portion outside of conditioned space.

VENTILATION

Mechanical ventilation can be likened to a home’s respiratory system. Ideally, it should draw in as much fresh air as it exhausts, and the fresh air should be free of contaminants upon introduction to the home. Mechanical ventilation is especially important in tight homes, so the 2012 IECC residential provisions, as well as various green building standards, all have basic requirements for mechanically induced, whole house ventilation, as well as for spot ventilation in kitchens and baths. While certain green standards incentivize higher quality whole house ventilation systems, none require more than the most basic, exhaust only strategy. Because ventilation systems vary widely in quality of air delivery, energy use and the manner upon which they act on envelope assemblies, the ventilation component is possibly the best example of what is known as the “House as a System” concept.

See page 15 for a table of typical whole house ventilation strategies and their attributes.
Whole House Ventilation Strategies

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exhaust Only.</strong> Typically provided with a bath fan running continuously or on a timed cycle. NOT RECOMMENDED, particularly when combined with “traditional air seal practices.”</td>
<td>Least expensive, both for first cost and operational cost.</td>
<td>Relies on building infiltration from unknown paths for “fresh” air. Creates pressure imbalance which can force moisture into envelope assemblies.</td>
</tr>
<tr>
<td><strong>Supply Only.</strong> Typically provided with a fresh air damper at the air handler return. Without a motorized damper and timer, this strategy relies on occupant to run system in “fan only” mode to provide routine ventilation. NOT RECOMMENDED.</td>
<td>Provides dedicated path for fresh air from outdoors.</td>
<td>More expensive than Exhaust Only. Energy intensive. Creates pressure imbalance which can force moisture into envelope assemblies.</td>
</tr>
<tr>
<td>Supply Only w/Air Cycler. Similar to above, but equipped with controls to provide routine ventilation without occupant intervention.</td>
<td>Provides dedicated path for fresh air from outdoors.</td>
<td>More expensive than Supply Only. May use more energy than Exhaust Only. Creates pressure imbalance which can force moisture into envelope assemblies.</td>
</tr>
<tr>
<td>Balanced, typically with interlock between supply and exhaust devices.</td>
<td>Provides dedicated path for fresh air from outdoors. Does not contribute to moisture drive through wall assemblies.</td>
<td>More expensive than Supply with Air Cycler. Highest operating cost.</td>
</tr>
<tr>
<td>Balanced, with Energy Recovery (ERV). Recovers energy (heat) otherwise lost through typical ventilation means. Can be configured to also handle spot ventilation in bathrooms.</td>
<td>Does not contribute to moisture drive through wall assemblies. Saves energy by transferring heat between outgoing and incoming air.</td>
<td>Most expensive. Requires careful attention to design to ensure proper functioning.</td>
</tr>
</tbody>
</table>

Importance of Spot Ventilation

In addition to the general ventilation requirements discussed above, homes need an extra boost of ventilation capacity to handle temporary but high moisture loads.

**Bathrooms**

Exhaust fan systems in full baths should be designed to move no less than 50 CFM of air when activated, or 20 CFM of air continuously. If operation is to be intermittent, best practice is to choose a fan or control with a timer delay function that will allow the fan to run an additional 20 minutes after being switched to the off position. For additional assurance that the fan will be used regularly, interlock the operation of the light switch to the bath fan. To discourage occupants from disabling the fan, choose a quiet fan, as indicated by its sound, or sone rating. The quietest fans have sone ratings as low as 0.3 sones and are barely audible when operating.

**Kitchens**

In all cases, kitchen exhaust should vent to outdoors at a minimum rate of 100 CFM. Recirculating range hoods do not effectively remove moisture and pollutants, such as vaporized grease and combustion byproducts.

To ensure that bath and kitchen fans can perform as intended, proper design and installation are critical. It is important to consider the length and path of the duct run. Tight turns and long runs can greatly diminish their effectiveness. If this is unavoidable, step up to a larger duct diameter. Upon installation, observe the dampers on outside walls during operation to ensure that they are freely operating without obstruction.
SPACE HEATING AND COOLING

Whereas many requirements imposed by codes and green standards add to construction costs, some of those costs can often be recouped by selecting right-sized equipment. Green standards, and now the 2012 IECC, require that a true HVAC load calculation be performed for the home in accordance with ACCA® (Air Conditioning Contractors of America) Manual J procedures, and that equipment is selected based upon the results using ACCA Manual S. The quality of insulation and windows, coupled with code-mandated, super-tight construction, means that heating and cooling can now be handled by much smaller equipment than before. The longer runtimes of smaller equipment allow for more effective removal of excess humidity from the home. Even so, it may still be necessary in some cases to install a dehumidifier to manage moisture.

Load calculations should be done with software, such as Wrightsoft or Elite RHVAC, not a spreadsheet. All inputs such as windows, insulation, orientation, ventilation, etc., should be confirmed as matching the home being built. Adding a safety factor is not necessary, as the software has already made such assumptions. It is important to trust the results.

It is not necessary, or even advisable to purchase the most efficient systems available, because the heavy lifting for home comfort is now being handled by the envelope. However, it is strongly advised that if heating with gas, furnaces are power-vented or closed combustion systems. While code permits the use of naturally drafted furnaces and water heaters, these appliances carry an inherent and serious risk for backdrafting of poisonous flue gases when installed in tighter homes. Green standards such as Enterprise Green Communities and LEED (Leadership in Energy & Environmental Design) for Homes® do not allow this outdated technology under any circumstances.

WATER HEATING

With heating and cooling loads minimized, water heating can become the most energy intensive process in the home. If the home is to have gas service, consider efficient, ENERGY STAR rated gas storage water heaters. If the budget permits, look at even more efficient systems such as condensing gas tankless or storage water heaters. For all electric homes, heat pump water heaters can deliver impressive savings, but it is important to locate heat pump water heaters away from living spaces, such as in a basement, because they draw heat from the surrounding space to heat the water.
OTHER DECISIONS

Although occupant behaviors are the biggest determinants to a home’s overall energy and water efficiency, certain decisions made at the time of renovation can greatly reduce unnecessary energy consumption.

LIGHTING
High quality, super-efficient LED (light-emitting diode) lighting is now readily available off the shelf, at highly competitive costs. For example, shallow, recessed fixtures offer the look and light quality of typical, recessed can lights, but at only a few inches of depth and comparable cost. This is a rapidly evolving technology. Monitor local home centers and lighting showrooms for what’s new. For quality assurance, choose ENERGY STAR rated fixtures and CFLs (compact fluorescent lamps).

APPLIANCES
ENERGY STAR refrigerators and dishwashers are available within a wide range of price points and typically are eligible for utility sponsored rebates.

Clothes Washers.
For energy and water savings, choose a machine with a high MEF (modified energy factor) and a low WF (water factor). Currently, all ENERGY STAR clothes washers must have a minimum MEF of 2.0 and a maximum WF of 6.0.

Dryers.
ENERGY STAR has only recently begun to rate clothes dryers so for now, these may be more expensive and difficult to locate. At minimum, select a dryer with moisture-sensing technology. To improve performance and prevent fires, vent to outdoors with hard ducting. Install the duct in such a way that it can be periodically cleaned of lint. If possible, avoid bends and long runs. Do not allow kinks or sharp bends.

WATER EFFICIENCY
Similar to lighting, a new generation of efficient, high performing water fixtures has entered the market. Backed by 3rd party performance testing, products such as toilets, faucets and showerheads bearing the U.S. Environmental Protection Agency’s (EPA) WaterSense® label promise outstanding performance, regardless of price point. Toilets with a flush rate of 1.28 gallons-per-flush (gpf) now easily outperform first generation low-flow, 1.6 gpf toilets. Satisfying showers can now be had with only 1.5 - 1.75 gallons-per-minute (gpm) shower heads.
HEALTHY MATERIALS
Indoor air quality is greatly influenced by products and materials introduced into the home. Some hard surface flooring, such as vinyl sheet goods and floor tile, are prone to emitting volatile organic compounds (VOCs). These fumes, often detectable by their odors, can cause respiratory problems in sensitive populations, even to the point of triggering asthma attacks. FloorScore certified products have been tested to ensure minimal risk of VOC exposure. Low-VOC products can be easily found in many other product categories, including paints and finishes, sealants, and cabinetry.

Over time, products such as cabinetry and flooring complete the off-gassing process and no longer pose a risk of VOC exposure. Purchasing salvaged products such as these for a rehab can support good indoor air quality, providing that any new finishes are confirmed to be low VOC. Materials reuse provides additional benefits to the community, such as job creation and waste diversion.

STORM WATER MANAGEMENT
Like most urban environments, the Greater Baltimore area is made up of mostly hard and impermeable surface area, leaving very few places where rainwater can be filtered through more natural surfaces such as plants and soils. As rain falls on rooftops, streets and other hard surfaces, it is channeled by sidewalks and gutters into storm drains and streams that ultimately lead to the Chesapeake Bay. As it rushes over distances, stormwater gathers heavy loads of pollutants and debris, delivering this toxic load directly into the Bay’s ecosystem.

The design goal is to retain and infiltrate stormwater on site as much as possible. While rowhome lots are small and may have very little permeable surface area, there are still measures that can be implemented to provide stormwater infiltration points. The most effective by far is to install a green roof on all or a portion of the roof area. While this may not be feasible in all cases, there are other smaller yet still meaningful measures that are easy to implement. For example, limiting parking surfaces to narrow strips of pavement, installing rain gardens and rain barrels, or even removing pavement to install tree pits or other green spots can all help to mitigate this region-wide problem.
As originally conceived, the rowhome was inherently a resource efficient dwelling because it combined urban density with shared walls and infrastructure. The rehabilitation of these homes allows us to reuse many of the materials and structure while also preserving a bit of history.

The concepts introduced in this guide are intended to lay the foundation for more sophisticated concepts in high performance construction, as well as higher levels of sustainability. Newer programs and standards currently on the horizon include Passive House, the Zero Energy Ready Home and the Living Building Challenge.

Passive House (PH) is a construction standard with extremely rigorous requirements for air tightness. Achieving the standard requires extraordinary attention to detail, eliminating virtually all points of air leakage in the building. PH also requires high performance windows and other envelope components, such as beyond code levels of insulation. Properly implemented, Passive House homes require extremely small amounts of energy for heating and cooling, so HVAC systems are small but sophisticated. As of this writing, there are Passive House certified rowhomes in New York, Pennsylvania, and elsewhere. The Baltimore rowhome lends itself well to a Passive House renovation, and there are several projects underway in the area that are anticipating PH certification. Many of the concepts in this guide were influenced by the building science of the Passive House community.

For more information, visit: www.passivehouse.us/passiveHouse/PHIUSHome.html

The DOE Zero Energy Ready Home (ZERH) is a logical next step for builders who have gained competency with ENERGY STAR 3.0 and are ready to step up to a higher standard of energy efficiency. ZERH builds on ENERGY STAR 3.0 and Passive House certifications. In addition to what is already a very high performance home, this certification also requires that the home is evaluated and potentially prepared for future installation of renewable energy systems such as photovoltaic (PV) panels for solar electricity production, or solar thermal panels for water heating. The ZERH certification also addresses indoor air quality by including the EPA Indoor AirPLUS certification as one of its requirements. It also encourages the use of EPA’s WaterSense program.

For more information, visit: http://energy.gov/eere/buildings/zero-energy-ready-home
For those striving for the greenest of standards, the Living Building Challenge (LBC) represents the most advanced thinking of all green building programs. Whereas the requirements of other green building programs offer to be less damaging to the environment, LBC is based on the concept of regenerative or restorative design. Regenerative design requires that the construction and existence of the building are actually beneficial to the natural environment. Among its requirements, the home must be net positive, meaning that all water used on site must be captured for reuse or otherwise managed on site as wastewater. Notably, materials must be free of any toxin included on the organization’s “red list.” This immensely challenging standard is appealing to those wishing to build or live in an extremely green home.

For more information, visit: https://ilbi.org/lbc
GLOSSARY

ACH50 – Changes of air volume per hour when tested at 50 pascals of pressure. For example, 5 ACH50 = 5 air changes per hour.

Air Barrier – An air barrier prevents air from moving through an assembly. This is more of a concept than a single material. Many products are typically used for this purpose:

- Mechanically attached membranes, more commonly known as housewraps, such as Tyvek. Mostly suitable for framed wall applications. To be effective, they must be shingle-lapped and sealed with tape at all edges.

- Spray foam insulation, closed-cell, minimum depth of 1.5”, open-cell, minimum depth of 5.5”.

- Fluid-applied membranes, such as heavy-bodied paints or coatings, including polymeric-based and asphaltic-based materials.

- Boardstock, such as 12 mm plywood, oriented strand board (OSB), or rigid foam board, often used to block airflow at bands.

Batt Insulation – Fibrous insulation in pre-cut panels used to insulate floors, walls, and ceilings. It is typically made of fiberglass, although rock wool is increasing in popularity. Natural cotton varieties are also available for thermal and acoustic installation. Fiberglass batt is the most widely used insulation because it is inexpensive. This product is easy to install poorly, difficult to install well. If installed properly, it can be an effective and long lasting thermal barrier.

Blower Door Test – A large fan with a pressure gauge is used to measure the air tightness of buildings. It can also be used to measure airflow between building zones, and to help physically locate air leakage pathways in the building envelope.

Bulk Water – Liquid water from precipitation, intruding into a building due to careless detailing of the building exterior, whether at the roof, walls, or foundation.

Duct Test - Also known as a Duct Blaster, this test is used to quantify the amount of conditioned air lost to outdoors due to duct leakage. 2012 IECC requires duct testing if any parts of the system are outside the thermal envelope.
**ERV (Energy Recovery Ventilator)** – A ventilating system that effectively preconditions the incoming outdoor air by transferring heat between incoming and outgoing, thereby recovering some of the energy that would otherwise be lost through ventilation.

**ENERGY STAR 2.0** – A now expired version of a voluntary energy efficiency certification program sponsored by the EPA. The certification requires inspections and performance tests at various stages of construction to confirm that the home will perform as expected.

**ENERGY STAR 3.0** – This current version of ENERGY STAR added many new requirements, most notably – HVAC system commissioning, mechanical ventilation, reductions in thermal bridging, and water management details for both interior and exterior applications.

**House As a System** – Just as the human body is a collection of integrated systems, so too is a home. For buildings, the systems include envelope, mechanicals, ventilation, plug loads, occupant behaviors – even external factors such as landscape shading, site drainage and climate. When a component or system fails, it can affect the health and performance of the whole. For example, certain conditions such as an unbalanced HVAC system can create room pressures that may drive moisture into wall cavities where it can condense and create conditions for mold.

**2012 IECC or 2012 International Energy Conservation Code** – Currently the most stringent energy code in the United States. It is one of many model codes written and regularly updated by the International Code Council (ICC). The codes are adopted voluntarily by various jurisdictions, sometimes with revisions. By law, the State of Maryland adopts the IECC and other codes without revision within one year of publication. Local jurisdictions within the State are permitted to amend the codes, providing the amendment does not weaken the energy requirements.

**Joist** – A horizontal supporting member that runs between foundations, walls, or beams to support a ceiling or floor. Typically, a beam is bigger than a joist and joists are often supported by beams laid out in repetitive patterns. In rowhomes, joists and beams are typically wood, and sometimes original to the structure.

**MEF and WF** – Modified Energy Factor (MEF) is the energy performance metric of a clothes washer that reflects the amount of dryer energy required to remove the remaining moisture content in washed items. The higher the MEF, the more efficient the clothes washer. Water Factor (WF) is the water performance metric of a clothes washer. WF gives number of gallons used per cycle per cubic foot. For example, if a clothes washer uses 30 gallons per cycle and has a tub volume of 3.0 cubic feet, then the water factor is 10.0. The lower the WF, the more efficient the washer.
**Parge coat** – A thin coat of cementitious or polymeric mortar applied to concrete or masonry for refinement of the surface. The typical parge coat is 1/4”-1/2” in thickness; this may be less than the minimum thickness allowed by many mortar types.

**Party walls** – A dividing partition between two adjoining buildings (or units) that is shared by the tenants of each residence or business.

**R-value** – A measure of a material’s ability to resist heat flow. The higher the R-value, the better the insulative value of a material.

**Thermal Barrier** – The insulation layer in a building assembly.

**Vapor Open/Vapor Closed** – A term applied to various assemblies which describes its ability to allow water vapor to pass through the assembly, rather than be trapped within where it may condense into liquid water.

**Water-Blown, Spray Foam Insulation** – Spray foam insulation that does not utilize ozone-depleting blowing agents.

**Windows, Casement** – A hinged window with sash that swings like a door, either side-hung (typical), top-hung (awning), or occasionally bottom-hung (hopper).

**Windows, Fixed** – An intentionally inoperable window (i.e., cannot be opened).