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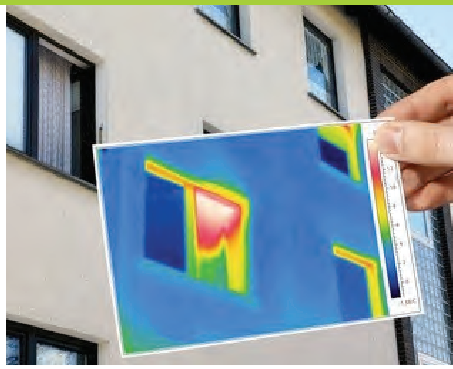
DRYVIT TECHNICAL BULLETIN



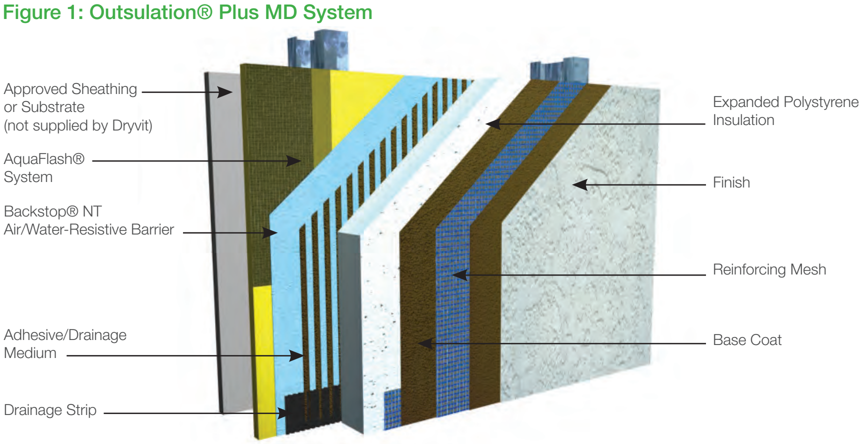
Energy Efficiency, Continuous Insulation and Outsulation® Systems

Architects today face numerous complex challenges, including the need to design in conformance with rapidly-changing model energy codes and mandates. The International Energy Conservation Code (IECC) is the most universally adopted energy code, which outlines the requirements for use and minimum thickness for cavity and rigid continuous insulation (ci) for all wall assemblies in all climate zones. This document examines the driving forces behind new IECC Energy Code requirements and presents a practical method for meeting them in a functional, cost effective, aesthetically diverse and sustainable way.

The Challenge: To cost effectively meet the latest energy code requirements, while maintaining aesthetic diversity in both new and retrofit construction.

The Solution: An Outsulation® system from Dryvit (Figure 1). Exhaustively tested and proven in the field for over 40 years, Outsulation systems are engineered to seamlessly integrate all the essential components of a high performance cladding – including liquid flashing, air and moisture barrier, provision for moisture drainage, continuous insulation, and durable, aesthetically diverse finish options. The entire system – flashing to finish – can be installed by a single contractor and is covered by a comprehensive warranty which can also include moisture drainage and sealants. Best of all, when the system is maintained under the Dryvit Platinum CARE program, the warranty can be extended for the lifetime of the building.

Figure 1: Outsulation® Plus MD System



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Buildings are the #1 energy consumer and CO_2 producer

According to the U.S. Department of Energy (DOE), buildings account for 39 percent of total energy use and 38 percent of total carbon dioxide (CO_2) emissions in the United States - divided about equally between commercial and residential structures. There are also millions of buildings built prior to 1980 which have little to no effective insulation in their exterior walls, and it is estimated by the DOE that 75% of these buildings will still be in use in 2050. These will require considerable exterior envelope maintenance - which will also present excellent opportunities to improve thermal performance.

Improving the energy efficiency of all buildings will reduce consumption of non-renewable fossil fuels, lessen dependence on foreign sources of that energy, and curtail greenhouse gas emissions. Through mandates such as the EPAct of 2005 and Energy Independence and Security Act of 2007, the Federal Government has aggressively raised the bar on energy-efficiency performance requirements of government owned buildings, and has recently taken further steps to encourage individual states to adopt the most current energy related building codes. Furthermore, all building owners, public or private, who construct or renovate with increased energy efficiency in mind reap the immediate benefit of increased property value and lower operating costs.

Making walls more energy efficient

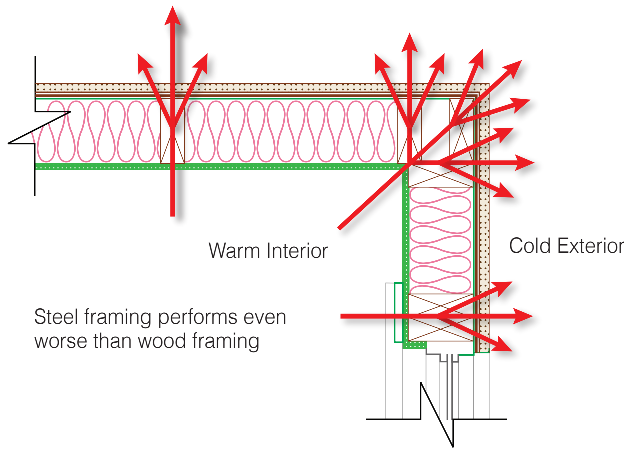
Thermal bridging. A typical framed wall assembly uses wood or steel studs with some form of cavity insulation – usually fiberglass batts. Although economical, this assembly is thermally inefficient because only the cavity (space between the studs) is insulated. The framing separates the insulation into non-continuous pockets and allows energy (heat) to conduct through the studs, bypassing the insulation and creating a condition called thermal bridging (Figure 2). Thermal bridging can reduce the effective efficiency of cavity insulation and steel framed wall assemblies by 50 percent or more!

Concrete masonry units (CMUs) are also widely used in structural exterior mass wall construction. CMU and concrete mass walls are a highly conductive (low R-Value) materials and allows energy to flow easily through the wall. Insulating CMU and concrete mass walls generally requires adding insulation in between furring channels, which are required for cladding attachment. The furring creates repeating thermal breaks, allowing heat flow to essentially bypass the insulated portions.

Eliminating thermal bridging in all building envelope assemblies can achieve significant performance improvements and thus, conserve energy.

Cavity Insulation. Cavity insulation provides little to no thermal benefit to framing members and other discontinuities in frame wall construction, and it is also easily compressed during installation which can further reduce insulation value as well as allow excessive airflow within the cavity. Over time, this type of insulation can also settle, sag, and absorb moisture, all of which contribute to reduced thermal performance.

Figure 2: Thermal Bridging Allows Heat to Flow Through Framing



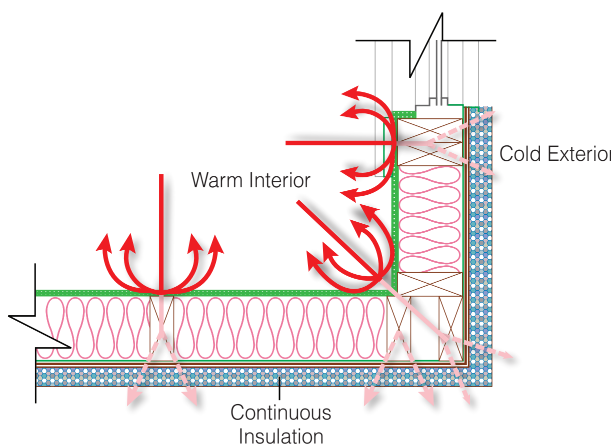
Air Infiltration / leakage. In most buildings, some unintended air flow (leakage) occurs through insulation joints, gaps, and penetrations in the building envelope. Air can flow into or out of the building and that can greatly impact energy efficiency as well as indoor air quality. Airflow in commercial structures varies widely according to building design and use, but it is estimated that air leaks are responsible for 25-40 percent of the energy used for heating and cooling a typical home.*

Air barriers and continuous insulation

A well designed wall assembly should seamlessly integrate an air barrier with continuous insulation (ci). (Figure 3). Placing these components on the outside face of the wall results in many benefits, including:

- Controlled energy flow
  - Prevents thermal bridging, increasing thermal performance
  - Moves dew point to outside of wall cavity, minimizing

Figure 3: Exterior Continuous Insulation Minimizes Heat Flow Through Framing



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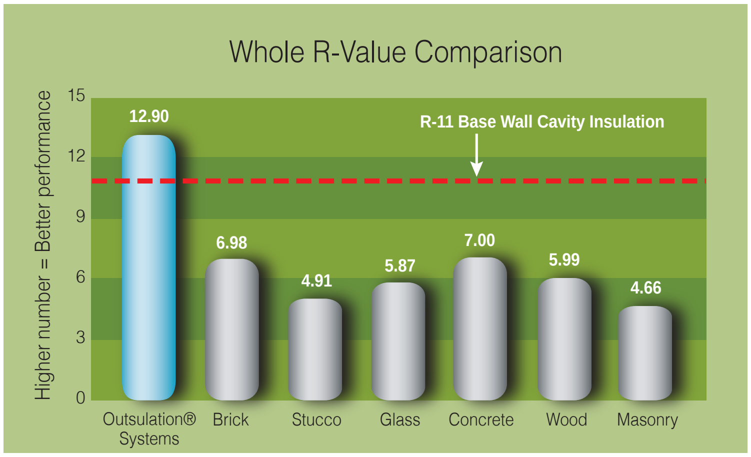
*Source: www.energystar.gov

Figure 4: Difference Between Rated R-Value (R-11) and Effective R-Value



Source: Oak Ridge National Laboratory (ORNL), 2002

  condensation potential and related damage
  - Reduces thermal expansion/contraction of framing, building movement, and associated stress
- Energy conservation
- Reduced operating costs
- Lower environmental impact

R-Value and thermal efficiency

The thermal efficiency of a material is commonly measured by its R-value. Values are assigned to insulation materials and expressed by a number (e.g., R-11) that represents the material's ability to resist thermal conductivity – and the higher the R-value, the better. But it isn't quite that simple. There is a misconception in the construction community that the new energy code requirements can be met by simply increasing the R-value of the cavity insulation. Nothing could be further from the truth; **continuous insulation** is required in most climate zones and especially in metal framed construction.

'Rated' vs. 'Effective' R-Values

Building scientists acknowledge that theory and practice can be widely divergent when it comes to quantifying the performance of insulation. Framed walls are typically designed and cavity insulation specified based on the insulation material's ***rated*** R-value. However, the rated R-value represents only the efficiency of the material itself and does not take into account the effects of thermal bridging.

The ***effective*** R-value of the cavity insulation, when installed between the studs, drops significantly – by 50 percent or more in steel framed walls and 24 percent or more in wood framed walls, because the effective R-value is based on the wall assembly as a whole – not just the insulation.

To demonstrate the effective R-value of cavity insulation in steel framed construction, a comparative study of rated vs. effective R-value in common wall designs was performed at the US Department of Energy's Oak Ridge National Laboratory (ORNL). Several common cladding types – including a Dryvit Outsulation system, brick, stucco, and wood siding – were installed over an identical stud-framed and R-11 cavity-insulated wall assembly. The study evaluated the "whole" wall construction, which included both the effects of thermal bridging and material / framing discontinuities, such as transition details and typical wall-accessory penetrations. (Figure 4).

The test wall using a Dryvit Outsulation system (with 2-inch-thick continuous insulation) was 84 percent more energy efficient than the next best performing cladding – brick veneer. The difference between the rated R-value of the wall cavity insulation (R-11) and the effective R-value of the brick veneer wall

Cavity insulation alone allows thermal bridging (left). Adding exterior continuous insulation prevents heat flow through framing (right).

Photos courtesy of The Dow Chemical Company

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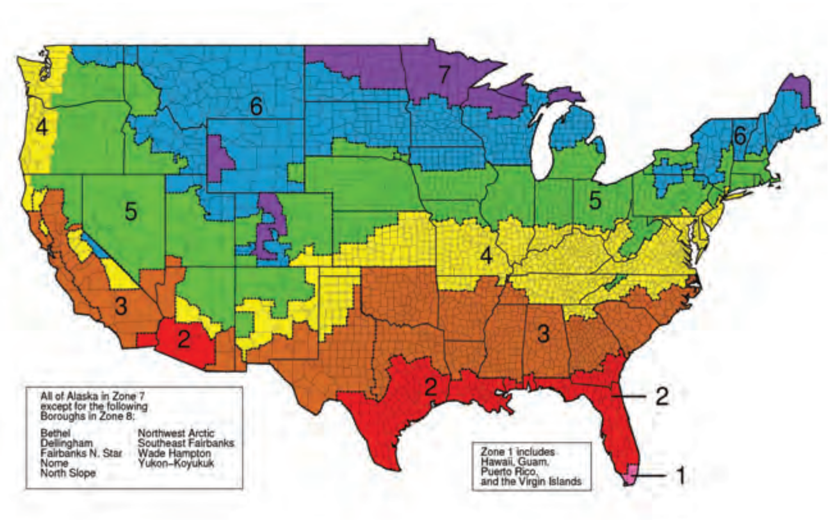
*Source: www.energystar.gov

assembly (R-6.98) is a direct result of thermal bridging and material / framing discontinuities. The study clearly demonstrates the negative impact of thermal bridging in wall assemblies which have only cavity insulation, and conversely, the significantly positive effects when continuous insulation is utilized.

A second illustrative example comes directly from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Design Standard 90.1, which is the driving force behind the model energy codes. ASHRAE Standard 90.1 specifically outlines effective R-value performance for insulation materials (e.g., cavity and/or continuous insulation), applies to all commercial buildings through its adoption into the IECC. Most specifically, the ASHRAE Standard 90.1-2010, as a result of previously mentioned government mandates, has been established by the Department of Energy (DOE) as the minimum energy code design guideline which all states are required to adopt by October 18, 2013.

For Commercial Construction, Table 1 from the ASHRAE Standard 90.1 shows that when used in steel frame construction (16” OC), an R-13 rated cavity insulation will only provide an effective R-value of 6.0 – a reduction of 54 percent! Furthermore, a rated increase from R-13 to R-19 (thicker cavity insulation) requires the stud depth be increased to a more costly 6 inches, and would only yield an effective insulation increase of R-1.1 - only 20 percent of the ‘perceived’ increase. Even more shocking is that an R-25 rated cavity insulation – requiring 8 inch framing - has only an effective R-value of 7.8 – a 68.8 percent reduction in the effective resistance and energy-efficiency performance.

Figure 5: U.S. Climate Zones (per IECC)



Deciphering Model Energy Codes

IECC. As part of the International Building Code (IBC), the International Energy Conservation Code (IECC) is the guiding force for building design and material requirements related to energy efficiency. As previously mentioned, the IECC bases its guidelines on and adopts the ASHRAE Standard 90.1.

Several different versions (2003, 2006, 2009 and 2012) of the IECC are currently adopted across the country, thus an architect must be aware of which version has been ‘adopted’ by the state or local jurisdiction in which the project is located. To determine the current version in use by a particular state, visit **http://www.iccsafe.org/gr/Pages/adoptions.aspx**. The IECC divides the United States into eight climate zones and establishes minimum requirements for the placement, and amount of insulating materials – cavity and

Table 1: Effective Insulation/Framing Layer R-Values for Wall Insulation Installed Between Steel Framing in Commercial Buildings

Nominal Depth of Cavity, in.	Actual Depth of Cavity, in.	Rated R-Value of Airspace or Insulation	Effective Framing/Cavity R-Value	
			At 16 in. on Center	At 24 in. on Center
Empty Cavity, No Insulation				
4	3.5	0.91	0.79	0.91
Insulated Cavity				
4	3.5	11	5.5	6.6
4	3.5	13	6.0	7.2
4	3.5	15	6.4	7.8
6	6.0	19	7.1	8.6
6	6.0	21	7.4	9.0
8	8.0	25	7.8	9.6

Source: ASHRAE 90.1 Table A9.2B

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Table 2: Prescriptive R-value Requirements – Commercial Framed Construction

Climate Zone	1	2	3	4 except Marine	5 and Marine 4	6	7	8
Commercial Construction								
Steel framed	R-13	R-13	R-13 + R-3.8 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI
Wood framed and other	R-13	R-13	R-13	R-13	R-13 + R-3.8 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-15.6 CI
Commercial Construction - Use Group R (Overnight Occupancies) Red values reflect increased CI requirements								
Steel framed	R-13	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-15.6 CI	R-13 + R-18.8 CI
Wood framed and other	R-13	R-13	R-13	R-13 + R-3.8 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-7.5 CI	R-13 + R-15.6 CI

Source: ASHRAE Standard 90.1-2010

Table 3: R-Value Prescriptive Requirements - Commercial Mass Wall Construction

Climate Zone	1	2	3	4 except Marine	5 and Marine 4	6	7	8
Commercial Construction								
Mass Wall R-Value	NR	R-5.7 CI	R-7.6 CI	R-9.5 CI	R-11.4 CI	R-13.3 CI	R-15.2 CI	R-25.0 CI

Source: ASHRAE Standard 90.1-2010

continuous - in the wall assembly (Figure 5).

At present, the most widely used IECC version is the 2009 with a number of states now beginning to adopt 2012. Both the IECC 2009 and 2012 through their adoption of ASHRAE Standard 90.1 as a minimum guideline, require continuous insulation for steel-framed wall assemblies in climate zones 3-8 for all commercial constructions. However, the IECC 2012 /ASHRAE Standard 90.1-2010 goes even further by separating out Commercial Use Group-R (overnight occupancies) by adding a requirement for continuous insulation in climate zone 2 and increasing the requirement for continuous insulation in climate zones 3, 7 and 8 (Table 2). Furthermore, IECC 2012 can now actually stand alone as its own energy code and includes even further increased requirements for continuous insulation (CI) in all climate zones and air barrier performance/building air leakage testing criteria. This now leaves architects and engineers a decision as to which energy code guideline - IECC 2012 or ASHRAE Standard 90.1-2010 - they wish to use for a commercial project.

The IECC permits two methods – prescriptive and performance - which may be used to determine the amount of necessary insulation for wall design.

The **prescriptive method** relies singularly on the rated R-value of an insulation material and identifies predetermined insulation requirements for various wall types and climate zones. For example, the IECC establishes minimum prescriptive R-values as previously mentioned for cavity and exterior continuous insulation for framed wall construction (Table 2) but also for continuous insulation for mass wall construction (Table 3) based on each climate zone. No further analysis or calculations are required.

The **performance method** is slightly more complicated. It is based on U-factor (which is figured as the fractional inverse of R-value – ie R-13 = a U-factor of 1/13, expressed by the decimal .0769) and accounts for all of the wall assembly components analyzed together in order to meet the climate zone's thermal performance requirement. **It is important to understand that both the prescriptive and performance paths generally have the same requirements for cavity and continuous insulation. Though different approaches, they have the same conclusions.**

Mandates, Design Standards, and Codes

In light of the federal government's stated goal of improving the energy efficiency of buildings (new and existing) – and specifically the initiatives set forth by the 2009 American Recovery and Reinvestment Act's State Energy Program and the DOE's mandate that all states must comply with ASHRAE Standard 90.1 – 2010 no later than October 2013 – future codes are expected to be more stringent from an energy efficiency standpoint.

As states adopt the newer energy codes, the changes reflected therein will be more dramatic in some areas than in others, resulting in major changes to thermal efficiency requirements.

Get on the Right Path

To determine the required prescriptive path for a particular project:

1. Identify the project's location by state.
2. Determine current IECC requirements for that state www.iccsafe.org/gr/Pages/adoptions.aspx.
3. Identify climate zone for project (Figure 5, Page 4).
4. Refer to Tables 2 and 3 (Page 5) to determine minimum prescriptive continuous insulation requirements.

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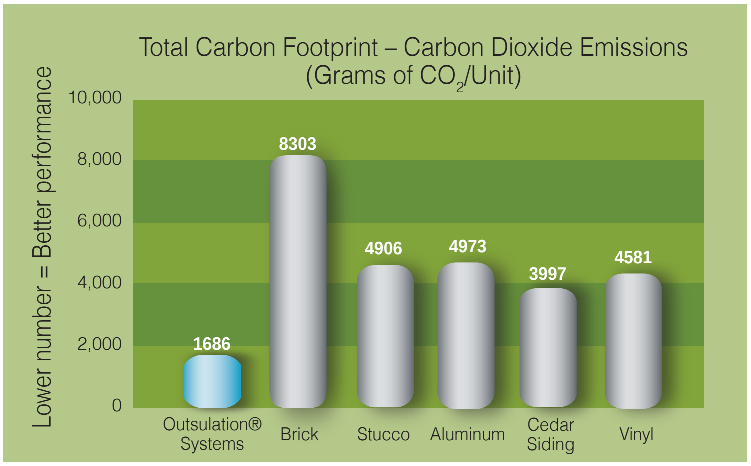
Figure 6: Total Carbon Footprint of Cladding Types



Source: National Institute of Standards and Technology (NIST, BEES v4.0 analysis, 2007)

As part of their focus on sustainable construction, it is highly likely that future building codes will continue to increase the requirements for thermal efficiency as well as the use and thickness of continuous insulation (ci).

Outsulation Systems by Dryvit – a single source solution to a complex problem

Able to satisfy the often divergent building design requirements of form, function, budget, and regulatory compliance, Outsulation Systems by Dryvit are the ideal solution for meeting model energy code requirements for increased thermal efficiency in exterior walls. These systems are unique in their ability to provide an air and water-resistive barrier, continuous insulation (ci) AND durable, aesthetically diverse finish options in a fully engineered, tested and proven system. They are equally well suited to new construction or renovation and perhaps most importantly, they pass the NFPA 285 fire test which is required for all framed wall construction that incorporates exterior continuous insulation, i.e. foam plastic.

Key Benefits of using Dryvit Outsulation systems:

Lower Construction Cost – Outsulation Systems weigh considerably less than most other cladding systems such as brick and stucco, which translates into a reduction in foundation and structural framing costs and a shortened construction cycle. Maximizing thermal efficiency also allows for a smaller, less costly HVAC system. To view a comprehensive case study, go to www.dryvit.com/mca.

Lower Operating Cost – Improved energy efficiency translates to less energy required to heat and cool the building for its lifetime.

Lower Environmental Impact – The National Institute of Standards and Technology (NIST) conducted a 50-year Life Cycle Analysis (LCA) (Figure 6) which concludes that an Outsulation System by Dryvit has an overall carbon footprint that is nearly five times smaller than clay brick veneer and nearly three times smaller than conventional stucco and the other tested claddings.

Contributes to LEED Certification – An Outsulation System by Dryvit can potentially assist in the contribution of as many as 37 points toward a building's LEED Certification (v3, 2009) through Credit Category areas such as Materials Resources (MR) for the Building Reuse, Construction Waste Management, Recycled Materials and Regional Materials credits; Indoor Environmental Quality (IEQ) for the Thermal Comfort & Design credit; Innovation in Design (ID); and, Energy and Atmosphere (EA). Most specifically, through the Energy and Atmosphere, Credit 1 - Optimized Energy Performance, Option 1 - Whole Building Energy Simulation, as many as 19 LEED Points can be earned for New Construction (NC) and Schools and as many as 21 LEED Points can be earned for Core & Shell (CS) type projects by demonstrating percentage (%) improvements to the building's overall energy performance when compared to the applicable building code as a baseline (Table 4).

Table 4: Outsulation Systems - Potential Contribution to LEED V 3.0

	NC	Schools	C&S
• **Materials and Resources**			
◦ Credit 1.1 – Building Reuse	1-3	1-2	1-5
◦ Credit 2 – Construction Waste Management	1-2	1-2	1-2
◦ Credit 4 – Recycled Content	1-2	1-2	1-2
◦ Credit 5 – Regional Materials	1-2	1-2	1-2
• **Indoor Environmental Quality (IEQ)**			
◦ Credit 7.1 – Thermal Comfort: Design	1	1	1
• **Innovation In Design (ID)**			
◦ Credit 1 – Innovation in Design	1-5	1-4	1-5
• **Energy and Atmosphere (EA)**			
◦ Credit 1 – Optimized Energy Performance	1-19	1-19	3-21
Total	**7-33**	**7-31**	**9-37**

Figure 7: Dryvit's Wide Array of Acrylic-based Finishes

Custom Brick™ | Lymestone™ | TerraNeo® | Quarzputz® | Sandpebble® Fine | HDP™ Finish | Reflectit™

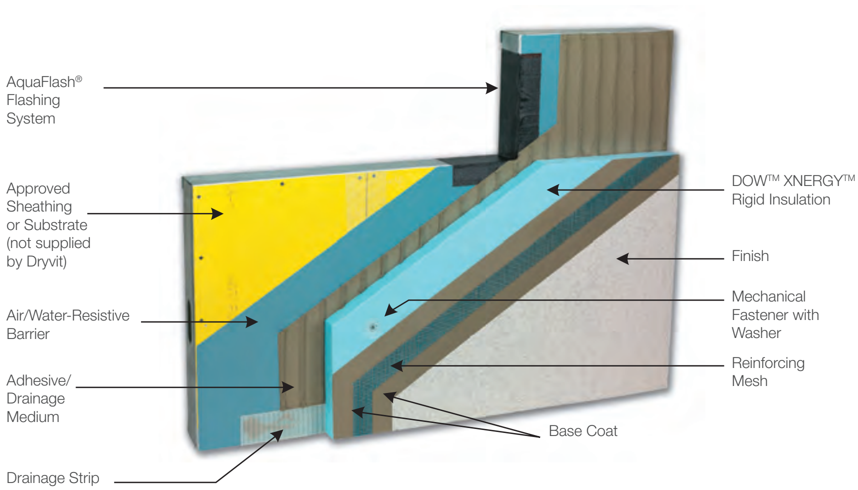
Architectural Diversity – The continuous insulation (ci) component of Outsulation Systems by Dyvit can be shaped, cut, and grooved to create multiple and diverse architectural styles. Using the latest in acrylic copolymer, UV resistant and hydrophobic chemistry, a Dryvit finish (Figure 7) can provide a variety of high performance characteristics with the appearance of stucco, limestone, granite, brick, and metal.

Single-Source Supply Installation and Warranty – Dryvit Systems, Inc. provides all components of the Outsulation System from 'flashing to finish' - providing the architect a fully engineered, integrated and warranted cladding system. In addition, the Outsulation System components are installed by a single sub-contractor, allowing the general contractor to more easily coordinate the installation. Finally, through the DryvitCARE? Platinum program, the building owner is eligible for a transferable, renewable warranty which can ensure maximum performance and peace of mind for the lifetime of the building.

Continuous Insulation (ci) Options – In addition to expanded polystyrene (EPS) insulation, Dryvit Systems has partnered with DOW Building Solutions and now offers extruded polystyrene (XPS) as the insulation component of the Outsulation? XTM system.

Advantages of DOW's XPS include a 50 year thermal performance warranty on the insulation board, higher R-value and increased impact resistance / durability (Figure 8).

Figure 8: Dryvit's Outsulation® X System



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Summary

Comprehensive changes have taken place in the building codes, and none are more important than those associated with increasing the energy efficiency of the building envelope. The need for improved energy performance, reduced energy consumption and lower environmental impact is dramatically affecting the way architects, contractors and building owners design, build and maintain new and existing structures, and as the requirements for the use of continuous insulation (ci) in all high performance wall assemblies become universal, it will become increasingly clear that an Outsulation System by Dryvit is an exceptional, long term solution.

Resources

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers): www.ashrae.org
Building Science Corporation: www.buildingscience.com
ICC (International Code Council): www.iccsafe.org/Pages/default.aspx
IECC (International Energy Conservation Code): www.energycodes.gov
IgCC (International Green Construction Code): www.iccsafe.org/cs/IGCC/Pages/default.aspx
LEED (Leadership in Energy and Environmental Design): www.usgbc.org/LEED
McKinsey Quarterly: www.mckinseyquarterly.com/A_cost_curve_for_greenhouse_gas_reduction_1911
National Institute of Building Sciences: www.nibs.org
NIST (National Institute of Standards and Technology): www.nist.gov/public_affairs/nandyou.cfm
USDOE (U.S. Department of Energy): www.energycodes.gov
USGBC (U.S. Green Building Council): www.usgbc.org

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