Net Zero Energy Homes

The next big trend in green building

INSULATION 101

ESTATES ECO International

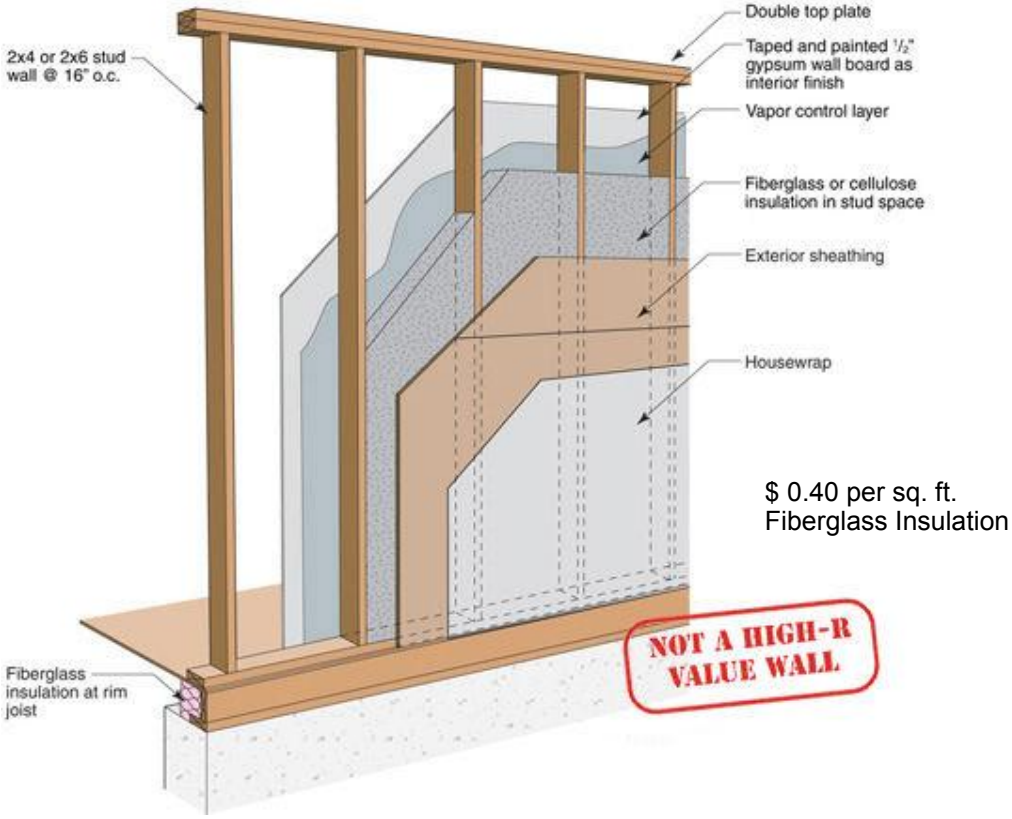
INSULATION OF A NET ZERO ENERGY HOMES – BY ECO ESTATES

This paper summarizes spray foam wall construction including the advantages and disadvantages of this construction strategy. The scoring system is subjective based on the relative performance and specifications between different wall systems. Complex two dimensional heat flow analysis and one dimensional hygrothermal modeling were used to determine moisture related durability risks for analysis.

Adequate insulation is critical to good energy efficiency. Simply put, it's easier to heat and cool a building that doesn't require as much heating and cooling.

There are four key insulation systems:

Batt Insulation — Fiberglass batt with an R Value of 3.14 per inch is the most common used type of insulation. A 3.5-inch fiberglass bat will provide an overall R-Value of 11 in a standard stud wall cavity.



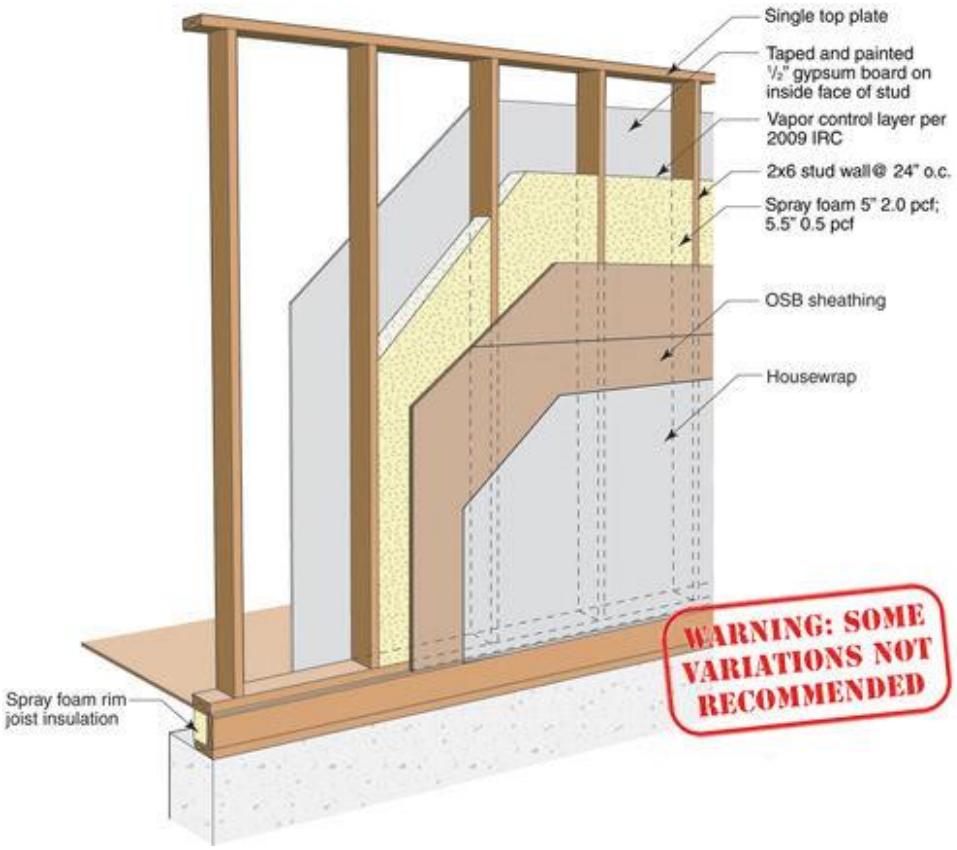
Loose-Fill (Blown) Insulation — This type of insulation consists of loose fibers that are blown into desired areas using special equipment. The fibers commonly consist of cellulose (treated with chemicals to prevent fire), fiberglass, and rock wool. This type of insulation typically has an R-3 per inch installed.

Spray Foam — While spray foam has an extremely high R-Value of 6.0 per inch, perhaps more importantly is it's proven ability to almost eliminate air infiltration. A study by the US Department of Energy shows that 40% of a homes' energy loss is due to air infiltration.

Rigid Insulation — A foil-faced polyisocyanurate sheet of rigid insulation will provide an R-Value of 7.2 per inch. The standard treatment of rigid insulation is as a sheathing on the homes exterior and under footings and slabs. Rigid insulation is used in conjunction with cavity insulation and serves as an excellent source of thermal blocking.

ENCLOSURES THAT WORK

High R-Value Wall Assembly: Spray Foam Wall Construction
2x6 wood frame wall at 24" o.c.
Spray foam cavity insulation (Closed-Cell)
OSB sheathing
Housewrap



OSB is made by blending rectangular wood strands with thermal-set, waterproof adhesives. The treated strands are arranged in cross-directional layers that are then pressed together under heat and extreme pressure. The result is a green, dense engineered panel that is stiff, strong and durable.

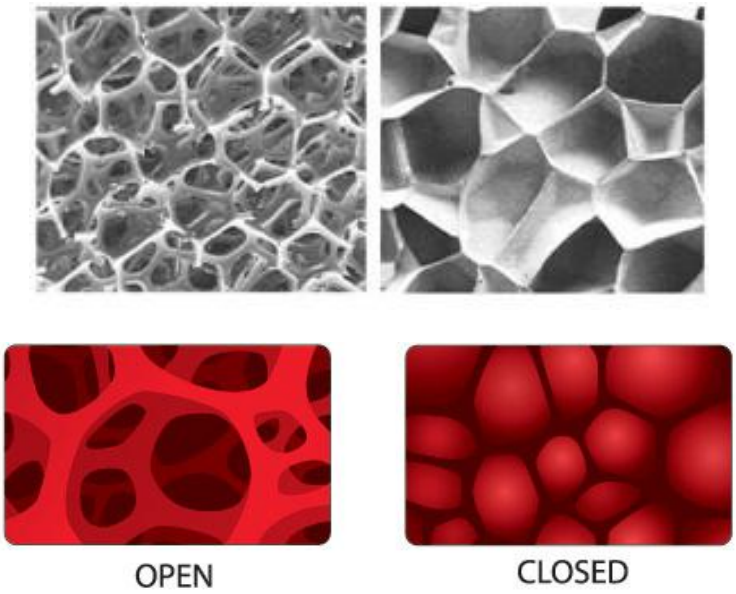
OSB won't cup, warp, split or delaminate as easily as plywood. You can count on consistent quality, without core voids and knots. Our OSB sheathing is uniform, strong, dense, and easy to work with. And LP OSB is environmentally friendly, using wood from small, fast growing trees. That means less waste and better use of resources.

Scoring: How It Rates

The scoring of the wall system is based on the following five categories. A score of 1 is the lowest score in each category and represents the worst possible technology for each category or highest possible relative cost. A score of 5 is the highest score available in each category, and is representative of the best available technology available on the market or lowest relative cost.

Thermal Control	5
Durability	5
Buildability	4
Cost	2
Material Use	4
Total	20

Both open-cell low and closed-cell high density foam increase the air tightness of the enclosure and reduce the risks to air leakage related durability risks. The R-values of both the low and high density spray foam are significantly reduced by thermal bridging of the wall framing and rim joist, demonstrating the value of insulated sheathing.



To learn more about either closed cell (right image) or open cell (left image) insulation we will list the benefits. For the most part, closed cell spray foam insulation and open cell spray foam insulation are named appropriately. The differences lie in the nature of the tiny bubbles of the polyurethane foam. Open cells have breaks in the tiny foam bubbles and closed cells, for the most part, employ enclosed cells, or bubbles. That difference means a few things. One of them is the density of the foam. Another is how hard the actual foam feels and the last is how the foam performs as an insulation product, a vapor barrier and an air barrier. All three of these last factors are the reason that we actually use spray foam insulation instead of more traditional insulation products. Closed cell foam has a higher R-value per inch of thickness. It also provides a greater performance as an air and water barrier. Due to the fact that it is also greater in density it is also more expensive to apply and also has a higher cost per effective

R-value than open cell foam insulation. Because of the greater density it is both heavier and harder when the foam cures. Open cell insulation is the choice most homeowners and business owners make when they are shopping ways to make energy efficient improvements. Because of the lower density and material cost per R-value, many people choose open cell for both retrofit and new construction. The r-value per inch of thickness is about 3.5 per inch, which is similar to fiberglass insulation, but the huge benefit is that even open cell insulation provides an effective air barrier. This is critical to how well the insulation performs. When applying spray foam insulation in a retrofit application in a home, the most common location to apply the insulation is on the underside of the roof deck. This serves many purposes, but one of the main benefits, besides amazing insulation, is to bring the air handlers and duct work inside the building envelope.

Open-Cell Spray Foam APPLICATION: Walls, ceilings, and roofs. The low density of open-cell foam makes it relatively vapor permeable (a 3-in.-thick layer of open-cell foam has a permeance of 16), so when it's used to create an unvented conditioned attic in a cold climate, the interior face of the foam should be covered with a vapor retarder. This can be accomplished by spraying the cured foam with vapor-retarding paint.

Open-cell foams use water or carbon dioxide as the blowing agent. Some open-cell foams are made in part from bio-based raw materials—for example, soybean oils—in place of a portion of the petrochemicals. Like closed-cell foam, open-cell foam creates an effective air barrier.

Unlike closed-cell foam, however, open-cell foam absorbs and holds water, has a lower R-value per inch, and is vapor permeable. The permeable nature of open-cell foam can be a virtue or a drawback, depending on the application.

Closed-Cell Spray Foam APPLICATION: Under slabs; walls (below grade and above grade); ceilings; and roofs. Closed-cell spray foams provide a higher R-value per inch than less expensive insulation types like fiberglass, cellulose, or open-cell foam, all of which have R-values of R-3.2 to R-3.8 per in. Closed-cell spray foam is the most expensive residential insulation. When installed well, however, it performs better than any other insulation. It is an excellent air barrier, is impervious to moisture, and is an effective vapor retarder. Because of its density and gluelike tenacity, it also adds structural strength to a wall, ceiling, or roof assembly. To seal air leaks in retrofit applications as well as new construction—for example, at rim joists or the attic side of partition top plates—closed-cell spray foam is an extremely useful material.

Closed-cell foam encapsulates a high-R-value blowing agent which acts somewhat like the argon in a gas-filled insulated window. The most commonly used and safest blowing agent is made by Honeywell Corporation; it's a non-ozone-depleting, environmentally benign chemical. This blowing agent produces a closed-cell foam with an aged R-value of about 6.2 per inch.

Thermal Control

Installed insulation R-value: The installed insulation R-value depends somewhat on the company and but generally speaking, high density foam (2.0 pcf) ranges between R-5.5-R-6.5 per inch for the aged R-value, and low density foam (0.5pcf) has an R-value of approximately R-3.6/inch. Since high density

foam is generally installed short of the cavity to avoid trimming, the installed insulation R-value is approximately R-30 (using R-6/inch). Low density is generally installed deliberately overflowing the cavity and trimmed off resulting in an R-value of approximately R-21.

Whole-wall R-value: Using two dimensional heat flow analysis with thermal bridging effects and average framing factors, it is clear that the thermal bridging through the framing, bottom plate, and top plate reduces the effectiveness of the spray foam insulation. The R-value of the high density spray foam wall decreases from an installed R-value of R-30 to approximately R-20, a decrease of R-10 because of thermal bridging. The low density spray foam wall decreases from an installed insulation R-value of 21 to a whole wall R-value of approximately R-16.

Air Leakage: Both low density and high density foam form an air barrier decreasing thermal losses through air leakage. Air leakage is still common under the bottom plate and at the rim joist if these areas are not detailed correctly.

Typical Insulation: Low density 0.5 pcf foam, or high density 2.0 pcf foam.

Durability

Rain Control: Rain control is typically addressed using a shingle lapped and/or taped drainage plane such as building paper or a synthetic WRB (i.e. homewrap). Intersections, windows, doors and other penetrations must be detailed to prevent the penetration of rain water.

Air Leakage Control: Air leakage is significantly minimized by installing spray foam insulation in the stud space since both low density and high density spray foam act as an air barrier. This increases the durability of the wall system considerably over standard construction.

Vapor Control: High density (2.0 pcf) foam forms a vapor control layer reducing vapor movement through the enclosure, minimizing the potential for wintertime vapor condensation and summertime inward vapor drive. Low density foam allows moisture vapor movement through the foam so other methods of vapor control such as poly, kraft paper, or vapor barrier paint may be required based on the geographic location.

Open-cell foam under roof sheathing can be risky. At a recent building science conference in Florida (Conference on Thermal Performance of the Exterior Envelopes of Whole Buildings XII, December 1-4, 2013), two academic papers were presented that shed light on questions surrounding the moisture content of roof sheathing that has been insulated on the underside with spray polyurethane foam.

One paper discussed a field study that found that even in a relatively warm climate (South Carolina), roof sheathing can accumulate moisture when open-cell spray foam is installed on the underside of the sheathing. Researchers speculate that exterior moisture (dew or rain) between the roof shingles is forced into the OSB roof sheathing by inward solar vapor drive.

The other paper reported on a computer modeling study that showed that when spray foam is installed on the underside of roof sheathing, open-cell foam is riskier than closed-cell foam in all U.S. climate zones.

Drying: Both of the spray foam walls dry relatively slowly if water enters the enclosure, since they do not experience convective looping and air movement similar to air permeable insulations. Spray foam does not provide any buffering capacity or redistribution. Foam is relatively moisture tolerant and will be able to dry given enough time. Ventilation behind vapor impermeable claddings and interior components (e.g. kitchen cabinets) can encourage drying.

Built-in Moisture: Care should always be taken to build with dry materials where possible, and allow drying of wet materials before close in. High density foam will inhibit the drying of wet building materials more than low density vapor permeable foam.

Durability Summary: The primary durability risks associated with these wall assemblies involve moisture damage related to rain water penetration. Both air leakage and vapor diffusion durability is significantly increased with spray foam but some vapor control may be necessary with low density spray foam in cold climates.

Buildability

Using spray foam as the stud space insulation is a very simple modification to the construction technique. Generally, the wall construction is the same as standard or advanced framing construction, and spray foam is sprayed into the cavity. Spray foam significantly reduces risks of poor air tightness detailing of the exterior sheathing or interior drywall.

Cost

Using spray foam will increase construction costs considerably but these increased costs may be outweighed by the benefits to energy efficiency, and occupancy comfort from reduced drafts.

Open-cell foams are permeable to moisture and impermeable to air at R-value per inch: about 3.6m and the cost: about $0.44 to $0.65 per board foot or $1 to $1.20 per sq. ft. Although open-cell foam costs less than closed-cell foam, it has a lower R-value per inch, so a thicker layer is required.

Closed-cell high density foams stop air and moisture at R-value per inch: about 6.5 and the cost: about $0.70 to $1 per board foot or $1.75 to $3.00 per sq. ft. Closed-cell foam isn't cheap, but it provides a much higher R-value per inch than open-cell foam. Because of its density and glue-like tenacity, it also adds structural strength to a wall, ceiling, or roof assembly.

Material Use

Wood framing required for spray foam insulation is the same required for the standard construction, or advanced framed wall depending on the framing strategy used.

Total Score

Both low and high density foam increase the air tightness of the enclosure and reduce the risks to air leakage related durability risks. A vapor control (ie. Poly, kraft paper, SVR) with high density foam is generally not required and vapor control with low density spray foam will be climate specific. The R-values of both the low and high density spray foam are significantly reduced by thermal bridging of the wall framing and rim joist, demonstrating the value of insulated sheathing. It may be possible to use spray foam insulation in combination with another insulation strategy to maximize the R-value gained with the spray foam insulation.

WALL SYSTEM at ECO ESTATES

The entire compilation of sheathing, insulation, vapor mitigation, and structural components is referred to as the wall system or wall assembly.

There are several different types of wall assemblies, each of which have advantages and disadvantages.

The standard 2x4 stud wall with ½" sheathing and batt insulation does not have enough advantages to outweigh its copious disadvantages. Unfortunately, most homes are built with this method. At EcoOne Homes, we seek and implement more modern, progressive, energy-efficient construction methods.

Most commonly, Eco Estates relies on 2x6 studs filled with closed cell high density spray foam, enveloped in 5/8" OSB sheathing. On the exterior, we apply a vapor barrier to the warm side of the insulation and add rigid insulation to the entire envelope.

Closed Cell High Density Spray Foam Performance:

- A high R-Value minimizes hot and cold spots in a home to improve efficiency and comfort.
- Rigidity provides added structural integrity to walls.
- As a secondary moisture vapor barrier, it helps reduce the risk of moisture intrusion in the wall cavity

Closed Cell High Density Spray Foam provides homebuyers:

- Outstanding energy efficiency
- Superior comfort and indoor air quality
- Enhanced moisture management
- Added structural integrity
- Excellent sound control

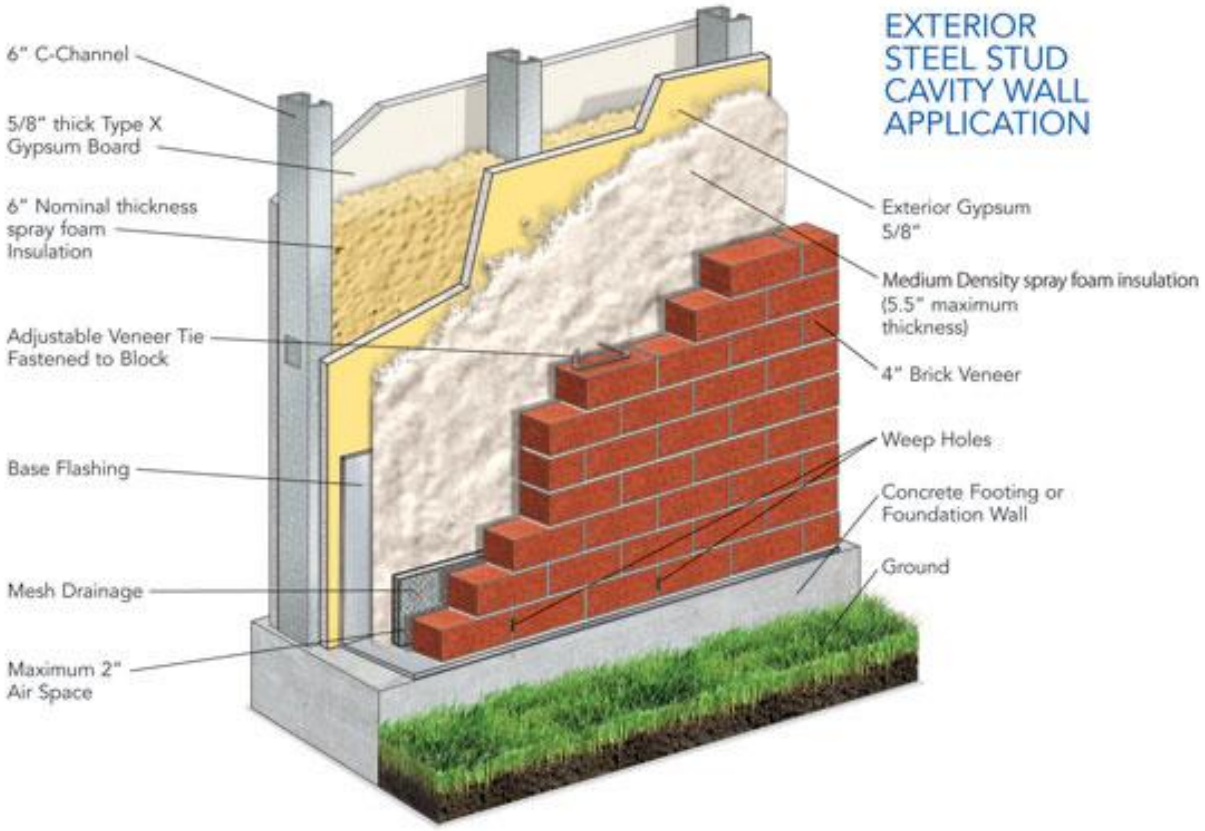
The closed cell 2-pcf foam can be spray-applied into open wall cavities, crawlspaces, perimeter joists, cathedral ceilings, and garage ceilings at a maximum total thickness of 6".

Our goal is a wall of an R-Value of R30-R40 compared with the typical R13 walls.

R value:

A product's r-value is its resistance to heat flow. A higher R-value prevents more heat from escaping through the insulation. Homes generally try and reach an R-value of 38 with their insulation. The R-value of spray foam insulation is approximately 6 per inch so you need insulation that is about 6.3 inches thick to reach R-38. The R-value of fiberglass insulation is approximately 2.2 per inch so you need much thicker fiberglass insulation to achieve the same R-value of 38.

	FIBERGLASS INSULATION	SPRAY FOAM INSULATION
How it works	Traps air inside tiny glass fibers, slowing transfer of heat.	There are 2 Types of Spray Foam insulation, Open and Closed Cell. Open Cell is mainly used as an air barrier but closed cell is an Air, Moisture and Vapor barrier.
Cost	Around $0.40 per square foot	Around $0.90-$1.50 Per Board Foot for Closed Cell. 1 Board Foot is a 1ft by 1 ft square at 1 inch of thickness
Air leakage	Yes	No with Closed Cell. Yes with Open Cell though minimal
Installation	Sheets placed in wall	Sprayed by a professional
Energy efficiency	Less efficient	Substantially More efficient
Flammability	Potentially, due to kraft paper on batts.	Yes – need a barrier with fire rating, like drywall. However, most Closed Cell Spray Foams come with a fire retardant.
Extreme cold	Loses heat quickly	No difference in performance
R-value	2.2 per inch non aged R-value. Fiberglass losses R-value over its lifetime	Open Cell - 3.5 per inch of aged R-value. Closed Cell - 6 to 7 per inch of aged R-value. Spray Foam does not lose R-value over its lifetime
Lifetime	10-25yrs if the fiberglass stays dry	+80yrs
Benefits	Low cost insulation	-Stops air and moisture infiltration - Adds strength to the building structure - It is permanent and will not sag - Keeps dust and pollen out - Reduces capacity requirements, maintenance and wear of HVAC equipment
Sound Barrier Efficiency	Low	High
Added Structural Integrity	None	Yes. Closed Cell adds up to 250% Racking strength to your walls and roof


EXTERIOR
STEEL STUD
CAVITY WALL
APPLICATION
6" C-Channel
5/8" thick Type X
Gypsum Board
6" Nominal thickness
spray foam
Insulation
Adjustable Veneer Tie
Fastened to Block
Base Flashing
Mesh Drainage
Maximum 2"
Air Space
Exterior Gypsum
5/8"
Medium Density spray foam insulation
(5.5" maximum
thickness)
4" Brick Veneer
Weep Holes
Concrete Footing or
Foundation Wall
Ground

ABOUT ECO ESTATES

Eco-Estates Custom Homes is amongst the most respected and well-known elegant net-zero energy zero-emission eco-friendly homes builders and in-house renewable energy installation services in North America. We are the leader in eco building and lead the way to a sustainable future. Ever since our inception, we have been dedicated to building spaces that reflect the personality and charm of all our clients. All through the years, our commitment to building the best eco- homes has allowed us to build a solid reputation honesty, trustworthy, dependable and professional where we are trusted by many of our loyal clients.

Being one of the best elegant net-zero energy zero-emission eco-friendly home (eco-home) builders in North America, we take it upon ourselves to make sure that we deliver nothing but the best. The eco-homes that we have designed and built over the years have made it possible for us to be known in the international green building industry as providers of innovative net-zero new homes that truly deliver great value for money. Every single elegant eco-homes that we build reflects upon the high standards of workmanship that we put in.

For more information, contact us for your free home solar audit or let us help you to build your dream home. You may like to stay with the leader of green building and renewable energy system by friend us on Facebook.

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