Energy Conservation Benefits of Air Barriers
StoGuard®

The Effect on Energy Conservation

By Chris Norris, P.E, P.Eng, LEED AP, CEI

Code requirements for air barriers are starting to be adopted on a state by state basis, but are not currently required in most states. With recent changes in energy codes continuous insulation is now required for frame construction in at least six out of eight U.S. climate zones, while there are continuous air barrier requirements in five out of eight climate zones. This paper presents a study that evaluates the energy conservation benefits of continuous air barrier systems relative to the benefits of increased insulation.

Energy Codes

Rising energy costs and environmental concerns have driven changes in energy codes and in construction practices, which are aimed at reducing energy consumption. Rising energy costs have also resulted in an increased focus on retrofit of existing buildings to reduce energy consumption. Controlling conductive heat transfer through exterior walls and controlling air leakage through the building enclosure are two key aspects to reducing energy consumption. Current US energy codes require continuous insulation for frame construction in at least six of the eight climate zones, and there are continuous air barrier requirements in five of the eight climate zones.

Historically U.S. state energy codes have focused on conductive heat transfer through prescriptive R-value and U-values for building enclosure systems. Lesser focus has been place on air leakage control and air barrier requirements. The first modern North American quantitative code requirement for air barrier materials was implemented in the National Building Code of Canada in the mid 1980's. In 2001 Massachusetts became the first state to incorporate a quantitative air barrier code requirement, Wisconsin, Michigan, Rhode Island, Georgia, Minnesota and Florida have since included air barrier requirements in their state codes.

Air Barriers

The specification of air barrier materials for exterior building enclosures is becoming increasingly common. The U.S. Army Corp of Engineers now requires that all new buildings, and all renovated buildings incorporate an exterior air barrier with maximum allowable air leakage of 0.25 CFM @ 1.57 psf.

There are several approaches to air barriers for exterior walls, of which combined air/water barrier materials are one of the more common approaches. Mechanically fastened house wraps, self-adhered membranes, and fluid applied membranes can all be used as an exterior air/water barrier for an exterior wall.

Fluid applied air barriers are often preferred by designers and installers for their relative ease of detailing and installation as compared to sheet goods. Fluid applied air/water barriers have long been used in drainable EIFS systems. The use of these fluid applied air/water barriers is now becoming increasingly common with other exterior cladding types. StoGuard, manufactured by Sto Corp. is an exterior fluid applied air/water barrier, and was part of an energy modeling analysis conducted by Morrison Hershfield.

Energy Modeling Objectives

The objective of the energy modeling was to evaluate the benefits of StoGuard air barrier systems for new construction and for energy retrofit applications as compared to typical construction without a defined air barrier. The StoGuard system provides a continuous fluid applied air barrier for exterior wall applications.

A prototype medium three-story office building was modeled for Dallas, Seattle, and Toronto climates. Various scenarios for retrofit of existing buildings and for design upgrades for new construction were considered. The baseline case buildings were modeled as meeting the minimum requirements of ASHRAE 90.1-2004 for existing buildings and ASHRAE 90.1-2007 for new buildings. A baseline air leakage rate of 1.55 cfm/sf of above grade envelope surface normalized to 1.57 psf (75 Pa) was used.[1]

Existing Building Baseline:

The baseline existing building was as follows:

- 53,600 sf three-story building meeting minimum ASHRAE 90.1-2004 requirements
    - Batt insulation in stud space for Seattle and Dallas, continuous insulation for Toronto climate.
    - 33% glazing (minimum code compliance for U-values, and SHGC values)
    - Air leakage rate: 1.55 cfm/ft^2 envelope area at 1.57 psf (75 Pa) pressure difference normalized to 0.08 psf (4 Pa).
- Steel stud framed exterior walls with brick veneer

Existing Building – Air Barrier Retrofit:

For retrofit case one a continuous 2” layer of rigid insulation was added to the baseline model without changing the air leakage rate. For retrofit case two, a continuous air barrier was added to the baseline model to achieve a reduction in air leakage rate to 0.4 cfm/ft^2 at 1.57 psf (75 Pa) pressure difference normalized to 0.08 psf (4 Pa). Exterior cladding and attachments were not included for this energy model study.

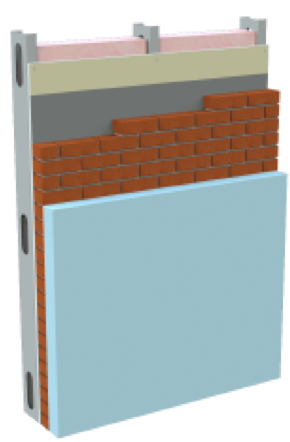


Figure 1: *Retrofit Case One*

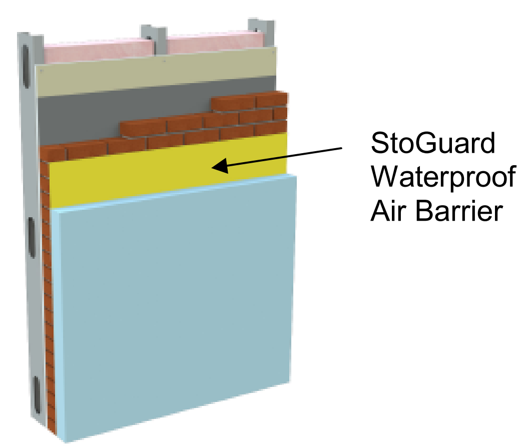


Figure 2: *Retrofit Case Two*

[1] ASHRAE 2009 Handbook of Fundamentals, p. 16.25

New Building Baseline:

The baseline existing building was as follows:

- 53,600 sf three-story building meeting minimum ASHRAE 90.1-2007 requirements
  - Batt insulation in stud space and continuous insulation (minimum code compliance level of insulation)
  - 33% glazing (minimum code compliance for U-values, and SHGC values)
  - Air leakage rate: 1. 55 cfm/ft^2 envelope area at 1.57 psf (75 Pa) pressure difference normalized to 0.08 psf (4 Pa).

New Building – Energy Design Upgrade:

The Energy Design Upgrade cases add a StoGuard air barrier system over the exterior sheathing and continuous insulation over the air barrier system. In all upgraded cases the air leakage rate was reduced to 0.25cfm/ft^2. The thickness of the exterior continuous insulation was varied from code minimum up to a maximum of 10" of insulation. Exterior cladding was not included in the energy model.

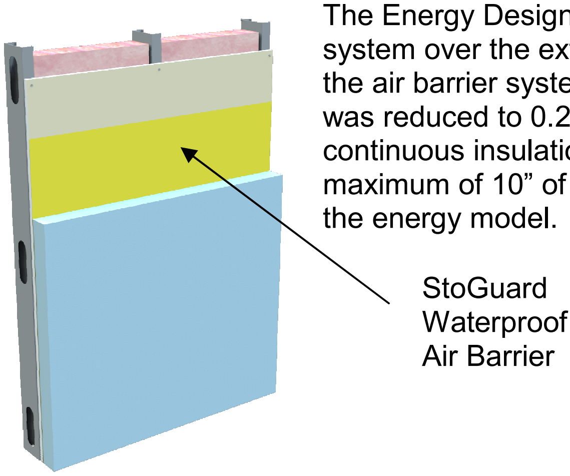


Figure 3: *Energy Design Upgrade*

Model Methodology

The prototype buildings used for the modeling were U.S. DOE Commercial Reference Buildings models, Version 1.3[2].

The Commercial Reference Buildings use the "Design Flow Rate" model for air leakage rate modeling. Air infiltration is assumed in perimeter zones only and air Infiltration is reduced to 25% of full value when the ventilation system is running. This modeling does not account for stack effect. Had stack effect been included a slightly higher air leakage rate would be expected.

While air leakage is typically specified and measured based on a differential pressure of 1.57 psf (75 Pa) across the building enclosure, the actual pressure across the building enclosure under normal operating conditions is substantially lower. For this reason, the air leakage rates used in the energy models are normalized to a pressure of 0.08 psf (4

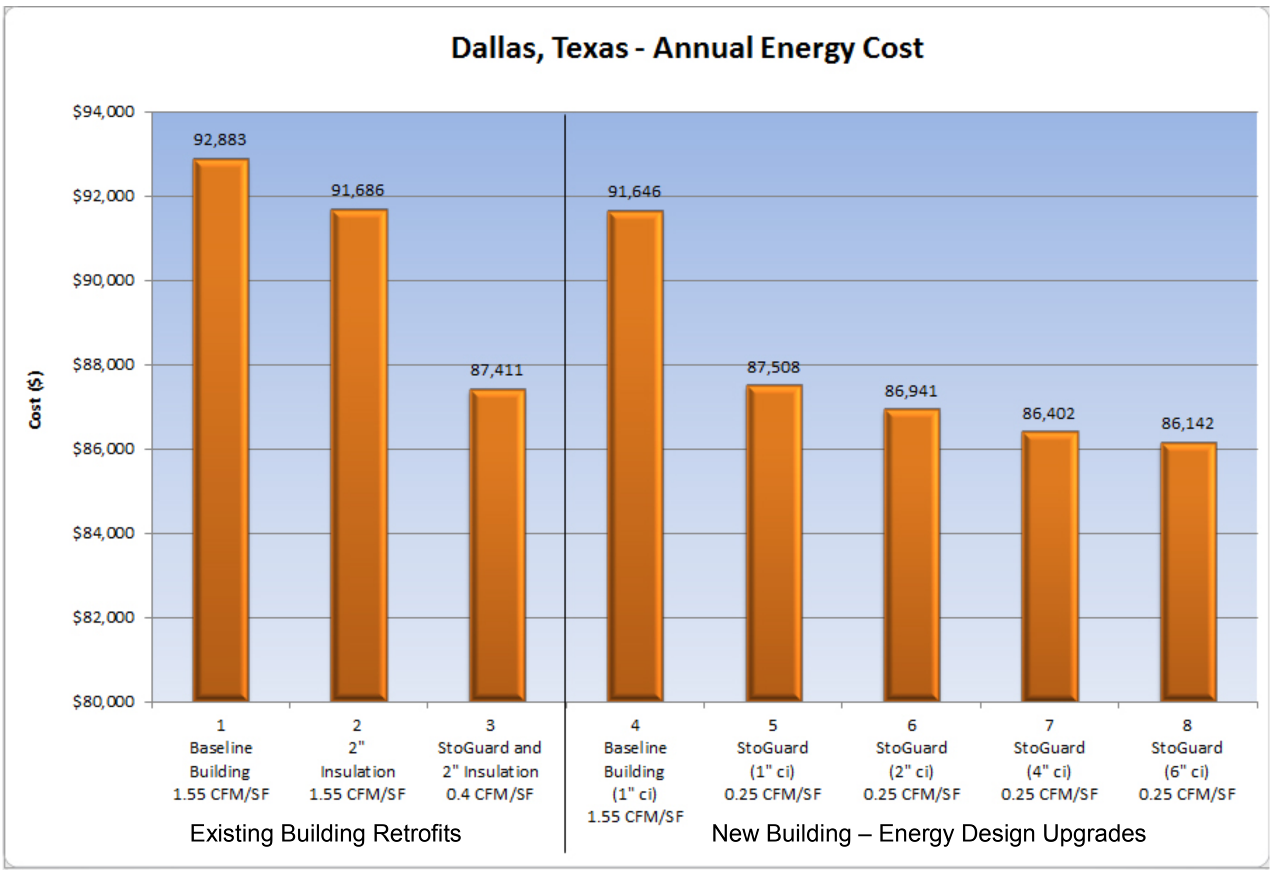
[2] Deru, M.; Field, K.; Studer, D.; Benne, K.; Griffith, B.; Torcellini, P; Halverson, M.; Winiarski, D.; Liu, B.; Rosenberg, M.; Huang, J.; Yazdanian, M.; Crawley, D. (2010). U.S. Department of Energy Commercial Reference Building Models of the National Building Stock. Washington, DC: U.S. Department of Energy, Energy Efficiency and Renewable Energy, Office of Building Technologies.

Pa) following U.S. Department of Energy guidelines[3]. Taking a base air leakage rate of 0.4 cfm/ft^2 of above grade wall area at 1.57 psf (75 Pa) and normalizing this to an air leakage rate at 0.08 psf (4 Pa) results in an air leakage rate of 0.0595 cfm/ft^2 of exterior surface area. The air leakage rates for the 0.25 cfm/ft^2 and 1.55 cfm/ft^2 at 1.57 psf were then scaled from this base case.

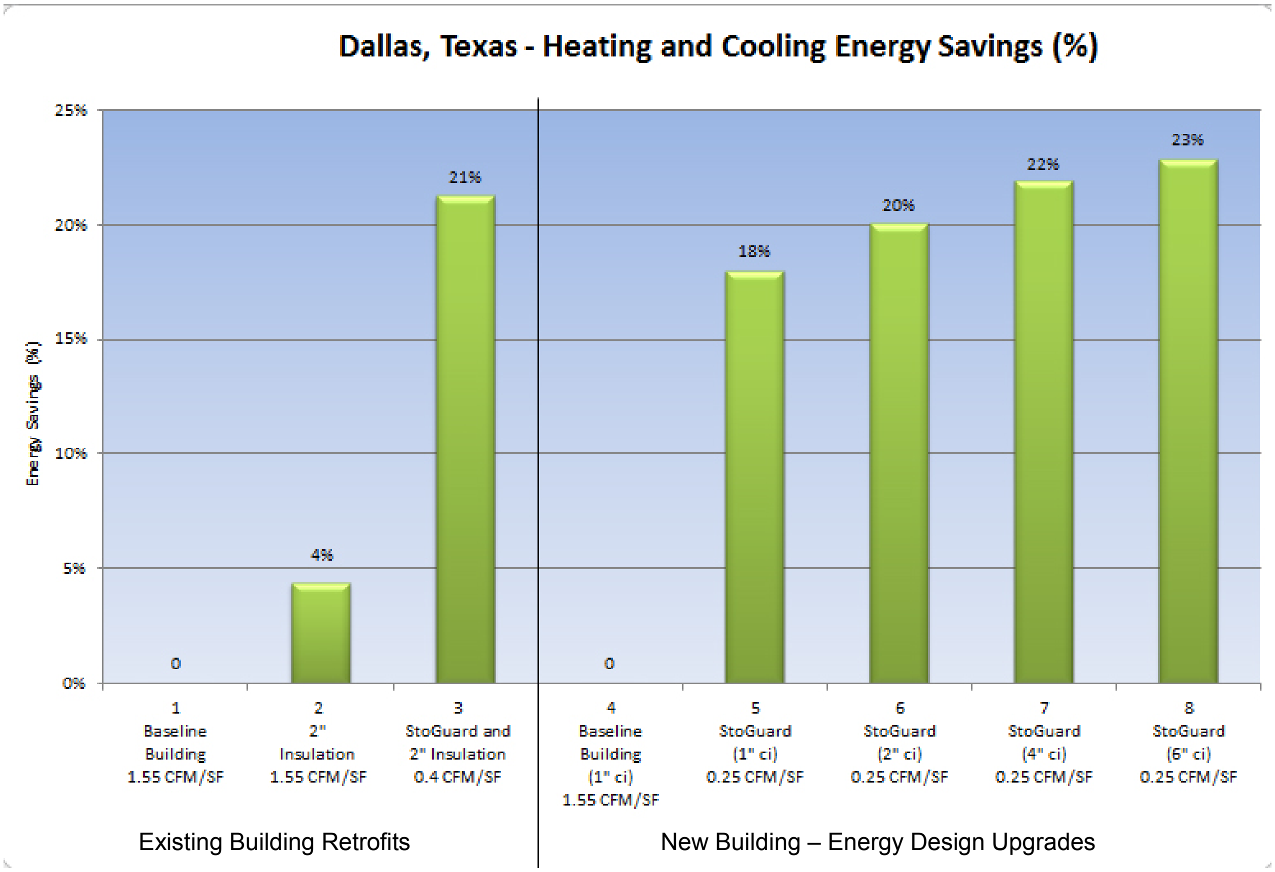
Heating, cooling, lighting, and interior equipment energy consumption were modeled for each load case at 10-minute intervals and the results are summarized on a monthly usage basis in units of kilowatt hours (kWh). This data was then used to calculate heating and cooling energy usage on an annualized basis. Annual energy costs, annual energy savings over the base case, and an annual carbon equivalent were calculated based on the annual heating and cooling costs.

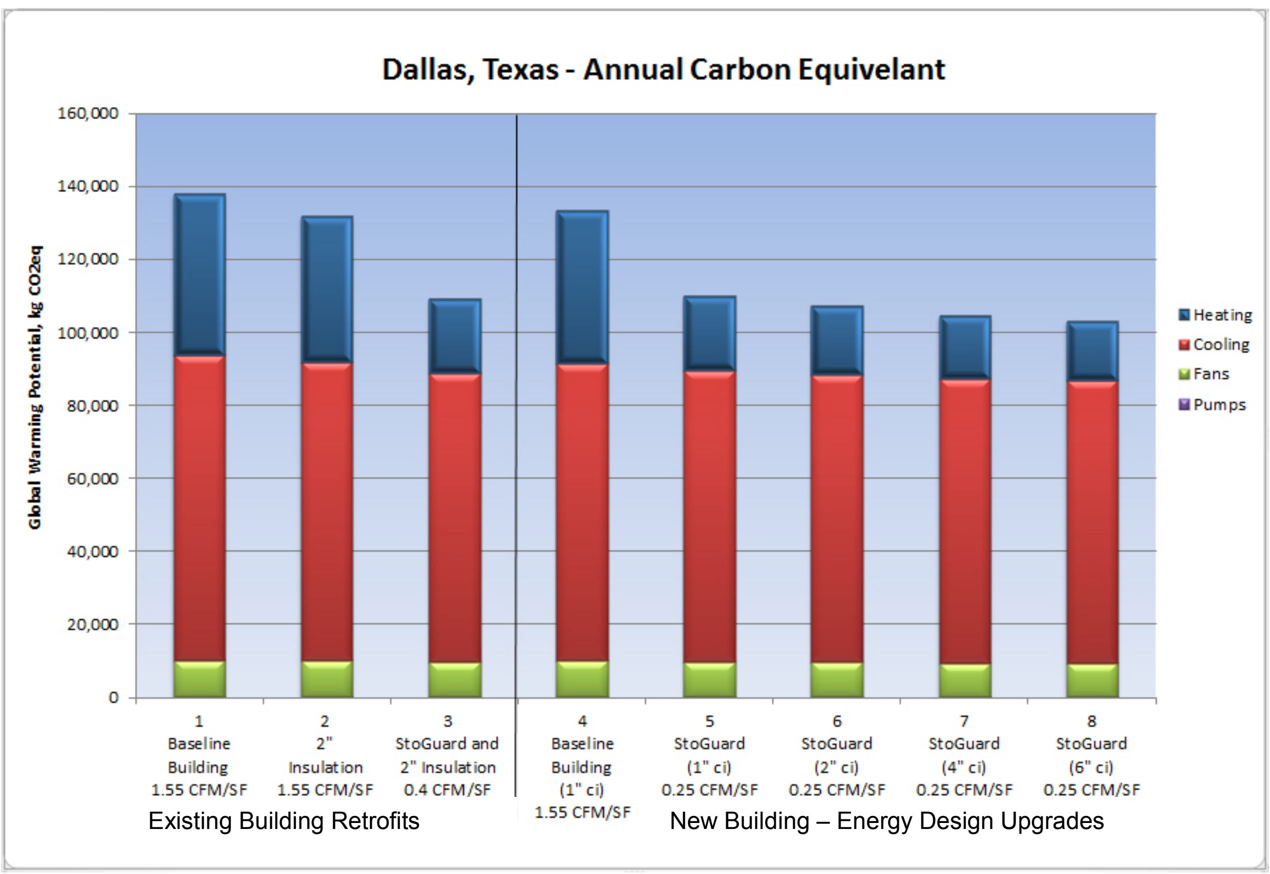
Energy Model Results

The energy modeling results are presented graphically in the following charts:



[3] The procedure is described in Gowri, K.; Winiarski, D.; Jarnagin. R. (2009). Infiltration Modeling Guidelines for Commercial Building Energy Analysis. U.S. Department of Energy Pacific Northwest National Laboratory.


Dallas, Texas - Heating and Cooling Energy Savings (%)
Energy Savings (%)
25%
20%
15%
10%
5%
0%
0
4%
21%
0
18%
20%
22%
23%
1 Baseline Building 1.55 CFM/SF
2 2" Insulation 1.55 CFM/SF
3 StoGuard and 2" Insulation 0.4 CFM/SF
4 Baseline Building (1" ci) 1.55 CFM/SF
5 StoGuard (1" ci) 0.25 CFM/SF
6 StoGuard (2" ci) 0.25 CFM/SF
7 StoGuard (4" ci) 0.25 CFM/SF
8 StoGuard (6" ci) 0.25 CFM/SF
Existing Building Retrofits
New Building – Energy Design Upgrades


Dallas, Texas - Annual Carbon Equivelant
Global Warming Potential, kg CO2eq
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Heating
Cooling
Fans
Pumps
1 Baseline Building 1.55 CFM/SF
2 2" Insulation 1.55 CFM/SF
3 StoGuard and 2" Insulation 0.4 CFM/SF
4 Baseline Building (1" ci) 1.55 CFM/SF
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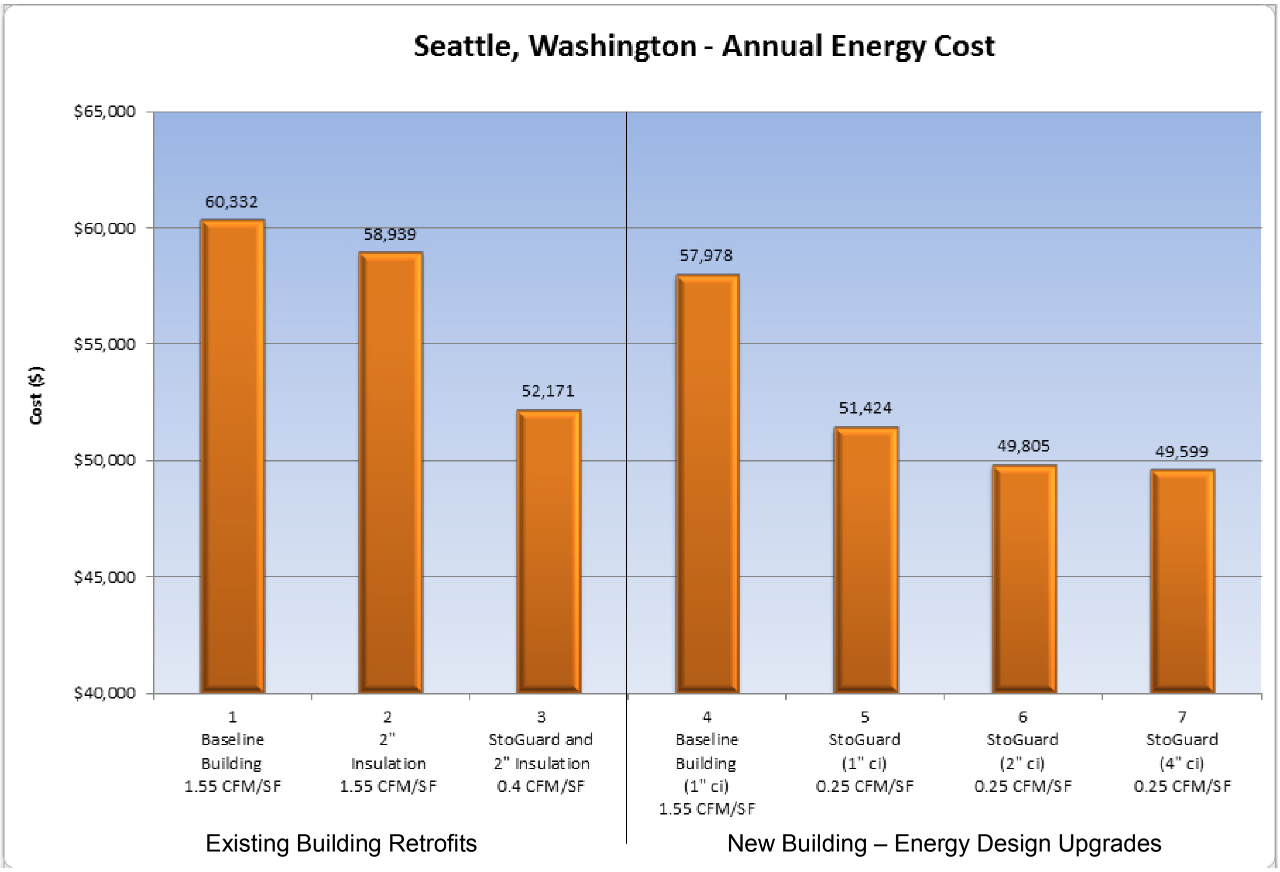
Seattle, Washington - Annual Energy Cost
$65,000
$60,000
$55,000
$50,000
$45,000
$40,000
Cost ($)
60,332
58,939
52,171
57,978
51,424
49,805
49,599
1 Baseline Building 1.55 CFM/SF
2 2" Insulation 1.55 CFM/SF
3 StoGuard and 2" Insulation 0.4 CFM/SF
4 Baseline Building (1" ci) 1.55 CFM/SF
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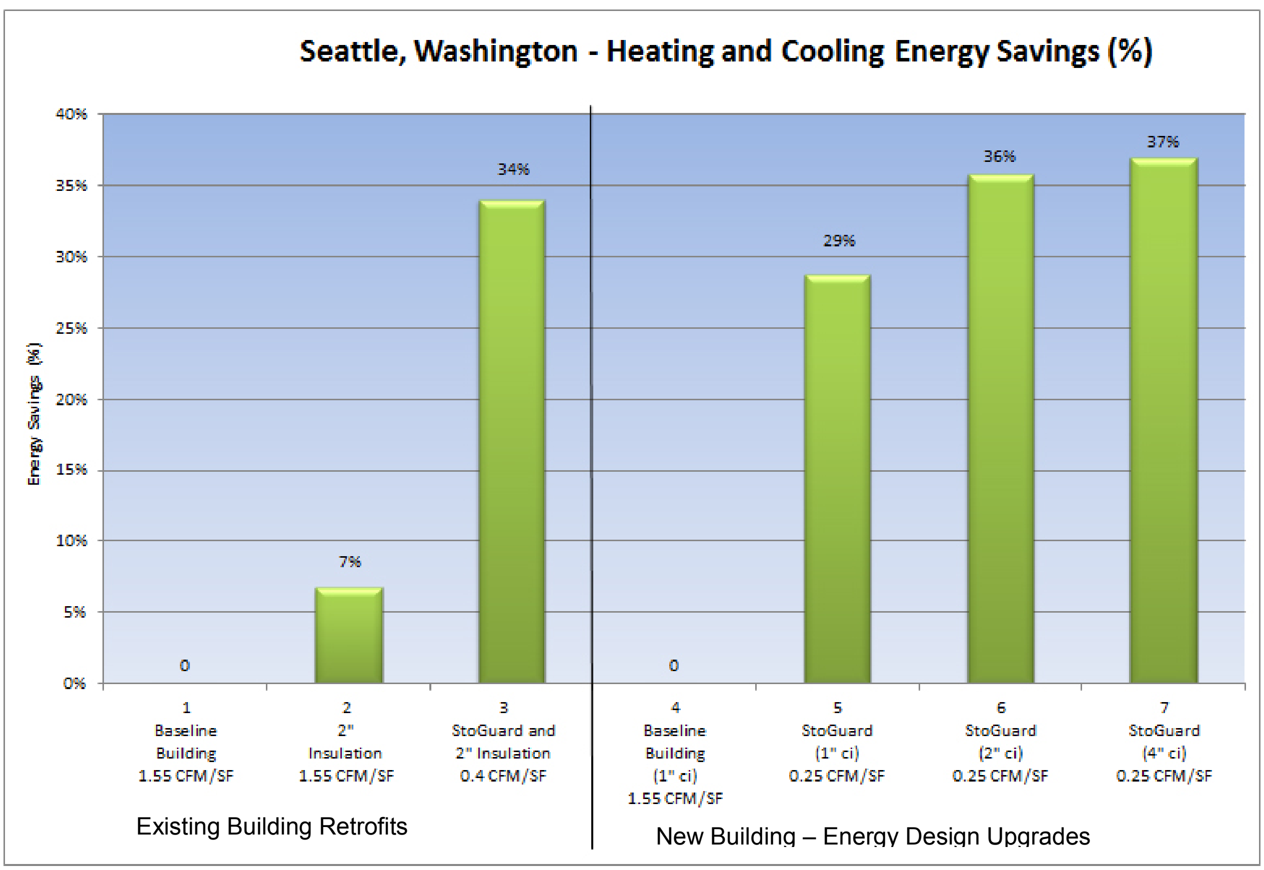
New Building – Energy Design Upgrades


Seattle, Washington - Heating and Cooling Energy Savings (%)
40%
35%
30%
25%
20%
15%
10%
5%
0%
Energy Savings (%)
0
7%
34%
0
29%
36%
37%
1 Baseline Building 1.55 CFM/SF
2 2" Insulation 1.55 CFM/SF
3 StoGuard and 2" Insulation 0.4 CFM/SF
4 Baseline Building (1" ci) 1.55 CFM/SF
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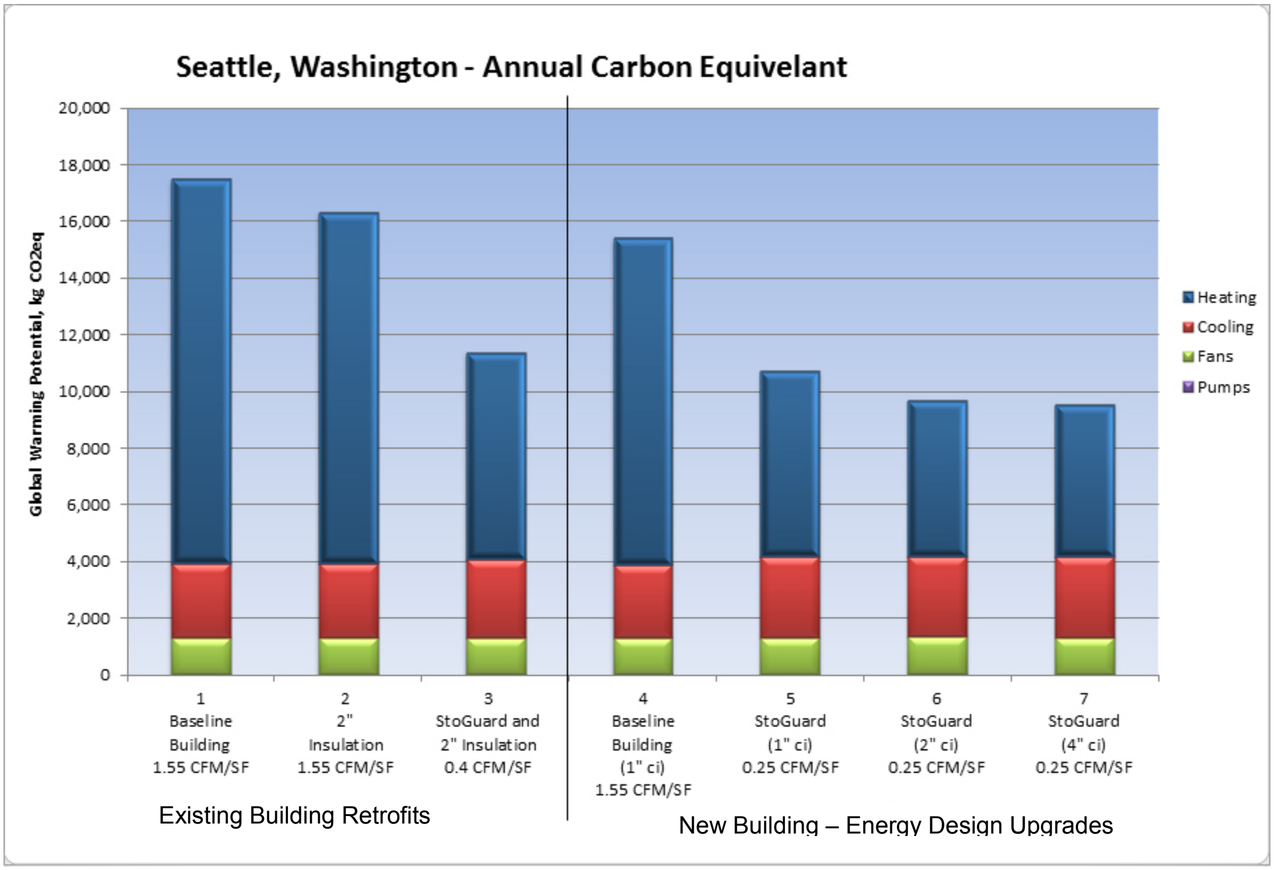
New Building – Energy Design Upgrades


Seattle, Washington - Annual Carbon Equivelant
Global Warming Potential, kg CO2eq
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Heating
Cooling
Fans
Pumps
1 Baseline Building 1.55 CFM/SF
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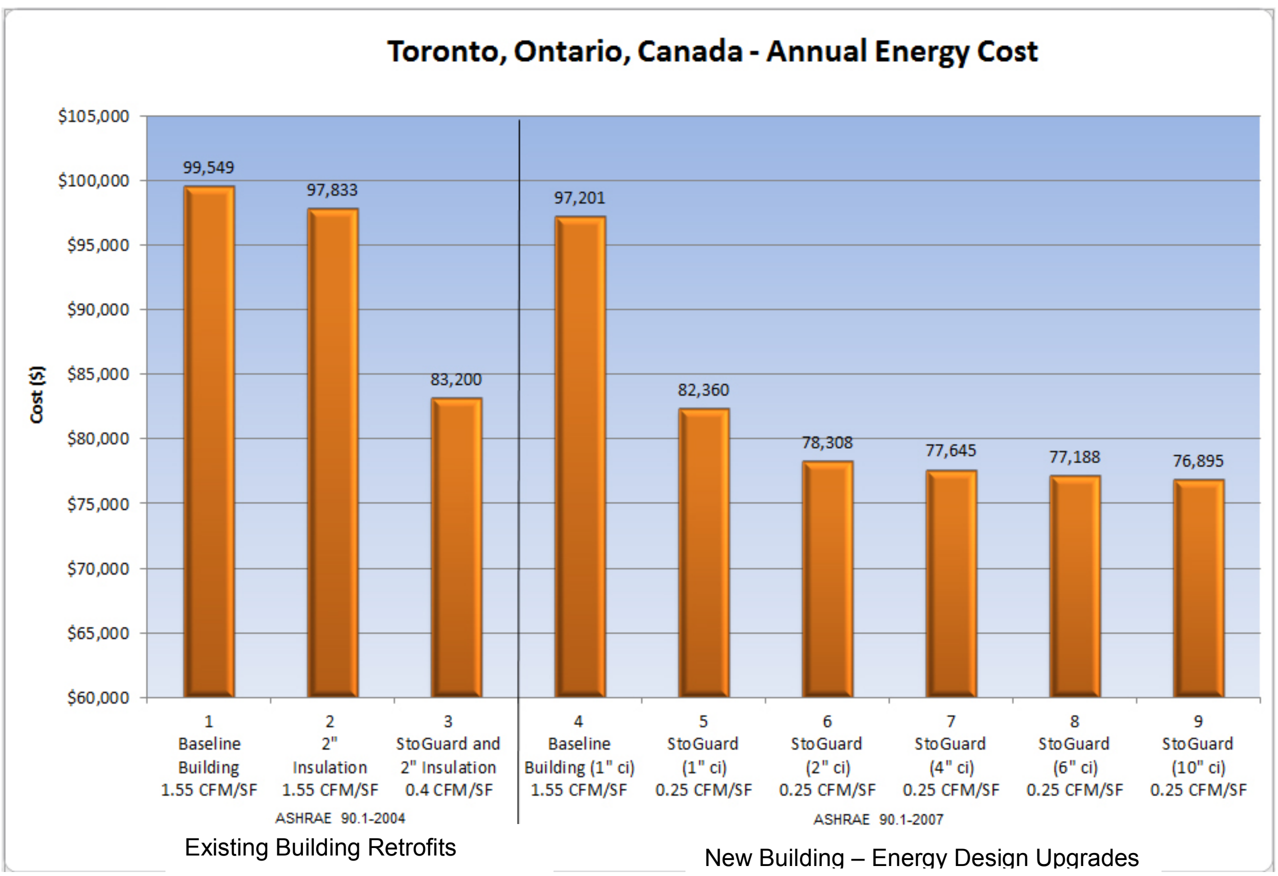
Toronto, Ontario, Canada - Annual Energy Cost
Cost ($)
$105,000
$100,000
$95,000
$90,000
$85,000
$80,000
$75,000
$70,000
$65,000
$60,000
99,549
97,833
83,200
97,201
82,360
78,308
77,645
77,188
76,895
1 Baseline Building 1.55 CFM/SF
2 2" Insulation 1.55 CFM/SF
3 StoGuard and 2" Insulation 0.4 CFM/SF
4 Baseline Building (1" ci) 1.55 CFM/SF
5 StoGuard (1" ci) 0.25 CFM/SF
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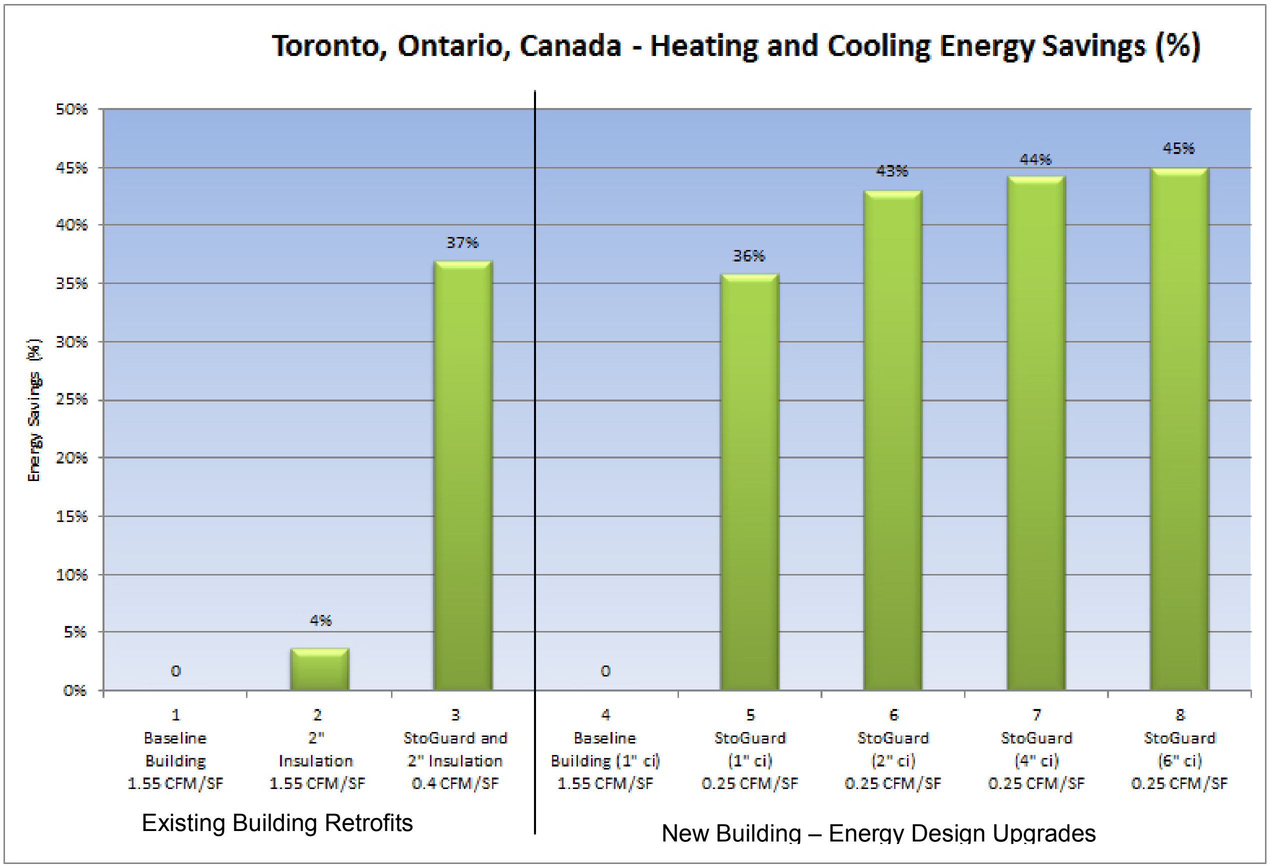
7 StoGuard (4" ci) 0.25 CFM/SF
8 StoGuard (6" ci) 0.25 CFM/SF
9 StoGuard (10" ci) 0.25 CFM/SF
ASHRAE 90.1-2004
ASHRAE 90.1-2007
Existing Building Retrofits
New Building – Energy Design Upgrades


Toronto, Ontario, Canada - Heating and Cooling Energy Savings (%)
Energy Savings (%)
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
0
4%
37%
0
36%
43%
44%
45%
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2 2" Insulation 1.55 CFM/SF
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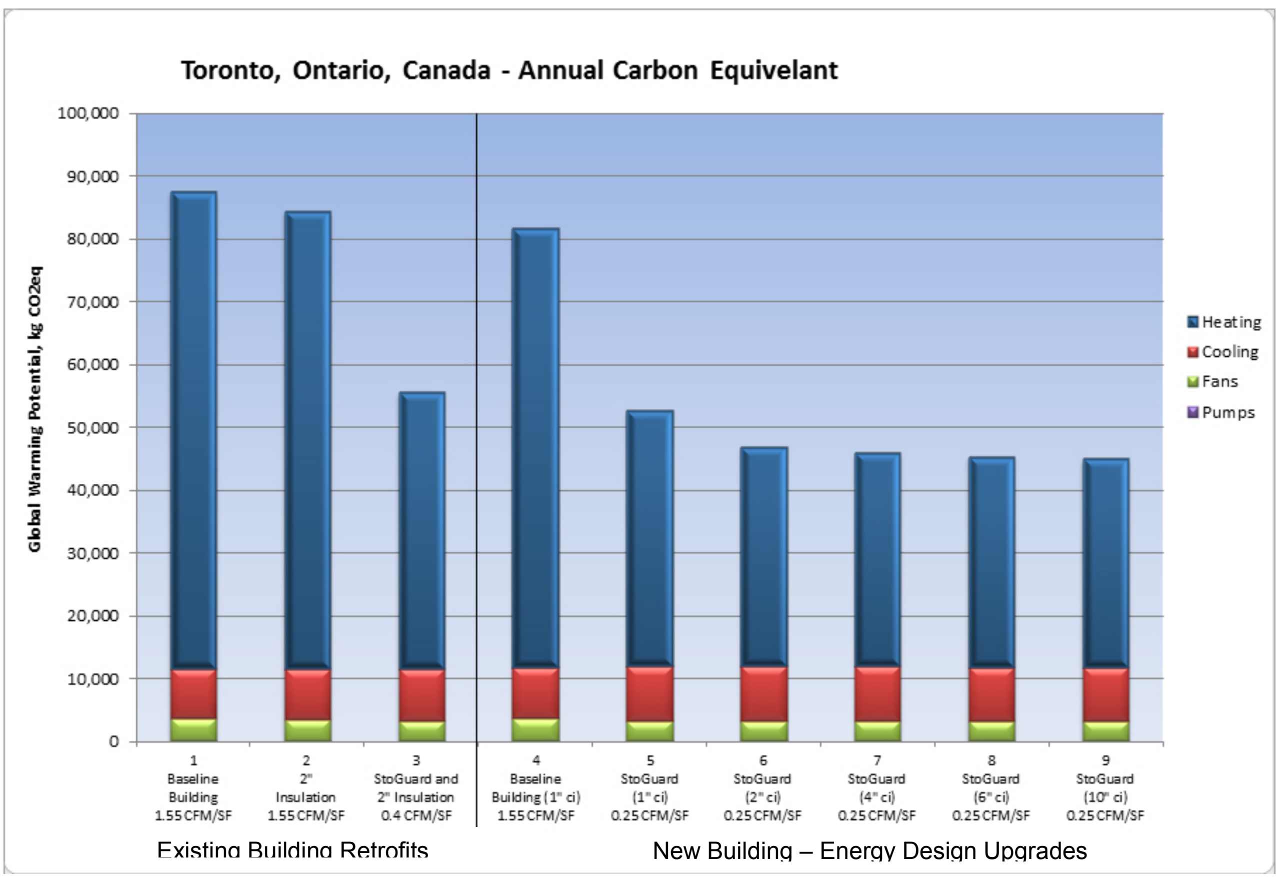
New Building – Energy Design Upgrades


Toronto, Ontario, Canada - Annual Carbon Equivelant
Global Warming Potential, kg CO2eq
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Heating
Cooling
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Existing Building Retrofits
New Building – Energy Design Upgrades

Key Findings

The following is a summary of key findings from the energy modeling:

New Buildings:

1. Substantial energy cost savings can be realized by adding a StoGuard air barrier system. The annualized energy cost savings by adding a StoGuard air barrier to a new building with code minimum insulation ranged from approximately $5,000 to approximately $19,000 with greater savings achieved in colder climates

2. The following annualized heating and cooling energy cost savings were realized by adding a StoGuard air barrier system with air leakage controlled to 0.25 CFM/sf @ 1.57 psf air barrier relative to a baseline ASHRAE 90.1, 2007 new building.

    a. Toronto: 36%

    b. Seattle: 29%

    c. Dallas: 18%

    The baseline ASHRAE building and the base StoGuard building were both modeled with the same amount of continuous insulation; the above energy cost savings are entirely attributable to improved air leakage control.

3. There is a diminishing return in energy cost savings as R-value (thickness) of continuous insulation is increased.

Existing Buildings

4. Adding a StoGuard air barrier to an existing building was found to have a much greater impact than adding insulation to an existing building.

5. The following annualized energy cost savings were attributable to improved air leakage control by retrofitting a baseline ASHRAE 90.1, 2004 building with 2" of continuous insulation and a StoGuard air barrier with air leakage reduced to 0.40 CFM/sf @ 1.57 psf.

    a. Toronto: 33%

    b. Seattle: 27%

    c. Dallas: 17%

6. There are limited cost savings by adding insulation without reducing air leakage. The annual cost savings by adding 2" of insulation, but not addressing air leakage varied from 4% to 7% depending on climate.

Conclusions

The modeling demonstrates that adding a StoGuard air barrier is an effective strategy to reduce energy consumption both for new buildings and for retrofit applications. Controlling air leakage has a larger impact on energy efficiency than increasing insulation.

Chris Norris is a Building Science Specialist with Morrison Hershfield. He leads new construction and retrofit building enclosure projects across the country.