BASF
The Chemical Company

Choosing Eco-Efficient Wall Claddings for Non-Residential Construction

A Comparison of the Environmental Footprint and Lifecycle Cost of Wall Cladding Systems Demonstrates the Eco-Efficiency of Exterior Insulation and Finish Systems

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In an effort to help architects, building owners and other interested groups select wall claddings for nonresidential construction projects, BASF – The Chemical Company conducted a comprehensive comparison of three commonly used systems. This scientific comparison, using a proprietary BASF process called Eco-Efficiency Analysis, evaluated the life-cycle, environmental and cost impacts of brick, stucco and a Senergy®* Exterior Insulation and Finish System (EIFS).

Wall designs, material take-off lists, maintenance schedules and all costs were provided by RS Means, the leading supplier of cost estimating information to the construction industry. RS Means, a division of Reed Construction Data, maintains an extensive database of cost data that has been created and maintained by engineers, covering 44 MasterFormat CSI divisions with over 120,000 lines of data.

The Analysis compared the ecological impact of each wall cladding in six key areas:

1. **Energy consumption**
2. **Resource consumption**
3. **Emissions**
4. **Land use**
5. **Health effect potential**
6. **Occupational illnesses and accidents**

** Senerflex Channeled Adhesive Design*

EIFS help the environment, provide architects enhanced design flexibility, and save building owners money

The information presented below is based on a comparison of two 3,000 square foot wall sections, one clad with EIFS and the other with single-wythe brick, over a projected 50-year service life. Both walls were equally insulated (U-0.077) and were supported at 12' intervals.

Assembly weight: The EIFS wall weighed 86% less than brick. This savings is further increased by potential frame and foundation weight reduction. The net effect is a much lower cost of construction and improved environmental benefits.

Greenhouse gases: This study determined that EIFS prevent 87,000 pounds of carbon dioxide equivalents from being emitted into the air, equal to the CO_2 uptake of 600 trees over a 50-year period.

Acid rain: Acid rain is a serious environmental problem that can damage lakes, streams, forests and the animals that live in them. EIFS can reduce the acidification potential caused by exterior cladding by more than 90%.

Water pollution: Water pollution is a major threat to aquatic biodiversity. The amount and burden of water emissions caused by EIFS is less than 20% of that caused by brick.

Resource savings: EIFS saves energy and reduces dependence on fossil fuels. In this comparison, EIFS consumed less than 20% of the fossil fuels used by brick.

Cost savings: The cost of EIFS was 28% of brick over the life of the building. This includes savings in initial cost, maintenance expenses and disposal costs.

Summary of Results

1. Senergy EIFS has the smallest ecological footprint in each of the six environmental impact categories. This is not surprising given that both brick and stucco construction are far more material-intensive than EIFS. Stucco is less material-intensive than brick, and offers an eco-profile that is greater than EIFS and less than brick.

2. The lifecycle cost of EIFS and stucco were much lower than brick. Brick was more expensive in all three phases- Production, Use and Disposal. Lifecycle costs for EIFS and stucco were similar, with EIFS offering lower cost as building height increases.

3. Brick provides the least eco-efficient wall cladding due to its high cost and large ecological footprint.

What is an Eco-Efficiency Analysis?

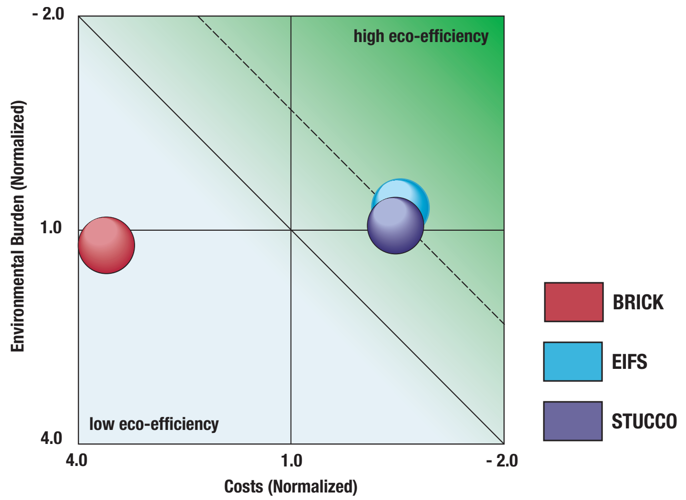
BASF's Eco-Efficiency Analysis methodology has been reviewed and validated by TÜV Berlin and NSF International*. It compares ecological and economic aspects of product or process solutions that fulfill a defined end-use function, over their entire lifecycle.

From an ecological perspective, a "cradle to grave" evaluation is performed. The environmental impact of processes involved in the extraction, conversion, maintenance and disposal of products are evaluated in six categories – Energy Consumption, Emissions, Toxicity Potential, Occupational Illnesses and Accidents, Resource Consumption and Land Use. In each category, a comprehensive set of ecological impacts are weighted and normalized, with the worst performing product defining a 1.0 score. Other products are ranked in relation to the lowest-performing product. In this way, a large amount of complex ecological data can be presented in an easily-understood format.

Complementing ecological assessment is a lifecycle cost analysis. Labor and material costs for product creation are combined with maintenance costs and the cost of final disposal or recycling. The end result is a balanced assessment of ecological impact and life cycle cost.

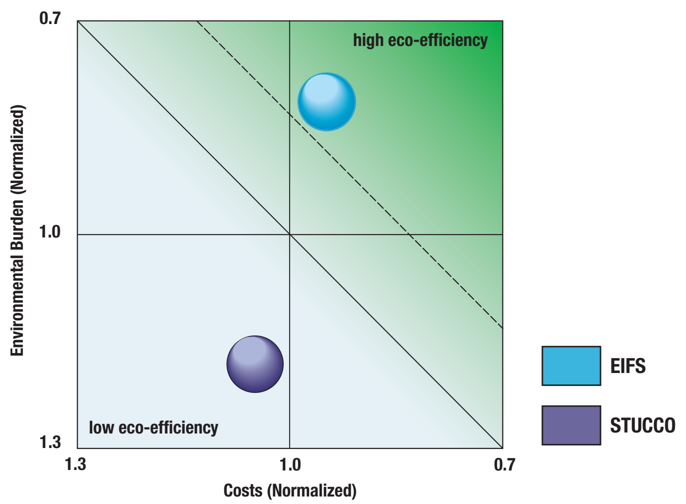
At a basic level, eco-efficiency means "doing more with less." It enables identification of efficient production processes and creation of better products and services, while reducing resource use, waste, and pollution along the entire value chain. BASF has conducted over 400 Eco-Efficiency Analysis studies worldwide, on an array of products and services, since the methodology was developed in 1996. From a construction industry perspective, Eco-Efficiency Analysis can help designers understand the implications of design decisions with a level of detail that was not previously available.

Eco-Efficiency Analysis results for the construction and 50-year use of brick, stucco and Senergy EIFS claddings on 12'- span metal infill construction



Brick's high cost skews normalized data, compressing environmental burden differences

Eco-efficiency comparison of stucco and Senergy EIFS



Rescaling data to consider only EIFS vs Stucco shows the smaller environmental footprint of EIFS.

* *http://www.nsf.org/business/eco_efficiency/models.asp?program=EcoEff*

Evaluating Wall Claddings

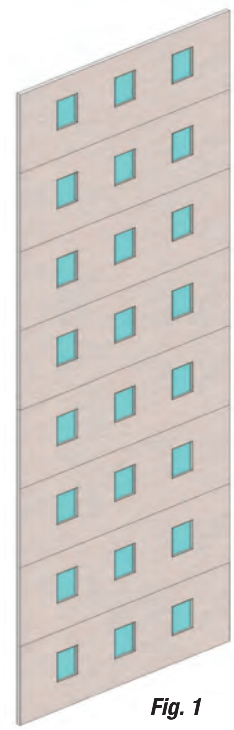


Fig. 1

Construction, use and disposal of a 3,000 square foot wall assembly, designed with steel stud framing and exterior-grade gypsum sheathing, formed the basis of this study. The assembly (Fig. 1) was 30' long by 8-stories high, with three windows per floor and a 12' span between supporting structures. To provide comparable impact resistance, the Senergy EIFS cladding was designed using Ultra-High Strength 20-oz mesh for the first 6' above ground level.

Elements of wall systems that were common across all three claddings, such as gypsum sheathing, were excluded from the comparison.

Reflecting emerging design practices, all wall sections were insulated to a level consistent with LEED Energy and Atmosphere performance targets[1]. All claddings used a fluid-applied air/water-resistive barrier, which is also a best design practice. By using the same insulation value and air/water-resistive barrier system for all three claddings, a direct comparison between materials of construction was achieved.

A 50-year service life was selected based on published data[2] and methods outlined in the Canadian Standards Association *S478 Guideline on Durability in Buildings* standard.

For the disposal phase, all materials were assumed to go to landfill. Although all three claddings are comprised of inert materials that are potentially recyclable, recycling strategies for building materials are at an early stage of development. Consequently this aspect was excluded from the study.

Span between supporting structures and allowable deflection were key considerations because they affect the amount of steel required to support the claddings. The allowable deflection used for EIFS, stucco and brick claddings were L/240, L/360 and L/600 respectively. For the 12' span used in this study, a heavier gauge of steel is required for brick cladding, and equal amounts of steel for EIFS and stucco. Larger spans would increase steel requirements for stucco and brick to a greater extent than for EIFS, due to their lower allowable deflections.
This would raise the relative cost, ecological footprint and weight of brick- and stucco-clad walls compared with EIFS. Brick-clad walls would be most heavily impacted due to their very low allowable deflection.

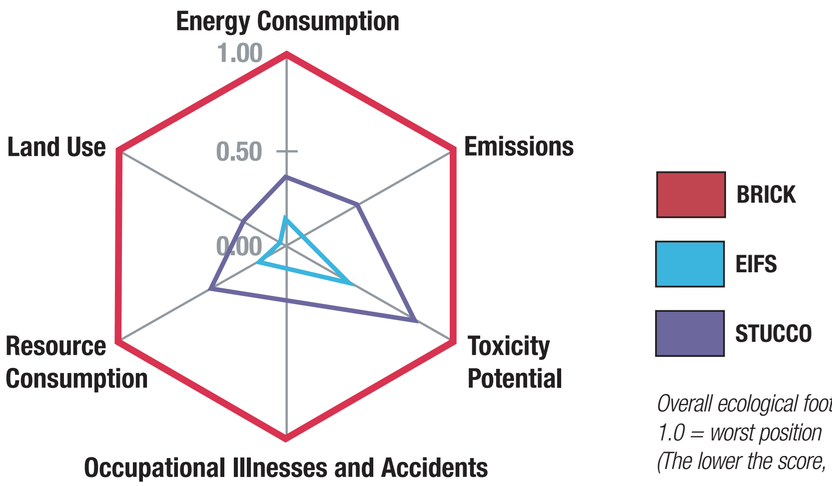
The effect of higher cladding weight on structural requirements of the building frame and foundation can also be a relevant factor, although it was outside the scope of this study. In projects where additional material is required for framing and foundations to accommodate heavier claddings, these requirements are likely to add to both cost and environmental impact.

Every construction project is unique in both design and location. Designers referencing this study should consider the effects of related variables such as those described above.

1. *Wall assemblies were insulated to meet the requirements of the New Buildings Institute Core Performance Guide for Climate Zones 1-6. For stucco and brick wall assemblies, 1" XPS was used to provide R-5 continuous exterior insulation, with R-13 fiberglass cavity insulation. The EIFS wall assembly was designed with 3" of EPS to provide a U-factor less than 0.077.*

2. *Long-term Performance of External Thermal Insulation Systems (ETICS), H. Künzel, H.M. Künzel, K. Sedlbauer, Fraunhofer Institute for Building Physics, Architectura 5 (1) 2006, 11-24.*

Results in each of the six ecological impact categories are as follows:



Overall ecological footprint results by wall cladding system.
1.0 = worst position
(The lower the score, the lower the environmental impact)

1. **Energy consumption**
   The wall assemblies evaluated in this study were designed with equal insulation values, so building energy consumption is the same in each case. This study analyzed cumulative energy consumption during the production, use and disposal phases, as well as the energy embodied in the materials themselves. Embodied energy, and energy consumed during transportation of materials to the jobsite and to end of life disposal were the largest contributors to overall energy consumption. The impact of transportation becomes increasingly significant as the total weight of the wall assembly increases.

   - **EIFS:** The Senergy EIFS wall assembly (including framing) weighs less than 14% of a comparable brick assembly, and 35% of a comparable stucco assembly. As a result, EIFS provide the lowest energy consumption.
   - **Stucco:** Though not as heavy as brick, the stucco wall assembly consumes almost 2.5 times more energy than the Senergy EIFS assembly.
   - **Brick:** The extremely high weight of brick results in the highest energy consumption. Key contributors are the energy requirements for transportation and the impact of extra lintels and heavier metal studs.

2. **Resource consumption**
   Resource consumption and Emissions were the environmental categories with the greatest relevance for this study. EIFS use the smallest amount of resources due to its ability to achieve desired performance with a very small contribution to overall building weight. Brick had the highest resource consumption due to high system weight and a requirement for resource-intensive materials such as heavier metal studs and steel lintels.

3. **Emissions**
Emissions were evaluated as discharges into air, water and soil. Senergy EIFS had the lowest total emissions in each of the three categories because of its low system weight, and because of the nature of the materials it employs.

Solid wastes, or emissions to soil, had the most relevance for this study. Brick generated the greatest emissions because of its high system weight. For air emissions, global warming potential had the highest impact. This was strongly influenced by the blowing agent used in the 1" extruded polystyrene insulation used in brick and stucco assemblies to control thermal bridging.

4. **Land use**
Land is not consumed like a raw material, but it can be changed so radically that its ability to perform its natural functions becomes impaired. Apart from direct loss of fertile land, ecosystems can be compromised and living space can be lost to flora and fauna. This study considered land area necessary to fulfill the customer benefit for each wall assembly. Land use impacts of materials such as steel, sand, brick, mortar, insulation and the fuel needed to transport materials to the jobsite and later to disposal were evaluated.

Solid waste emissions to landfill, the effects of transportation, and resource extraction had the largest effects on land use. The brick assembly had the highest impact in all of these categories. Overall, the Senergy EIFS assembly had the lowest impact on land use.

5. **Health effect potential**
The health or toxicity potential impact is determined using a BASF method based on European Union regulations. Health potential impact values were determined for all raw materials, intermediates and final products that are used during the lifecycle of each alternative, taking into account the likelihood of human exposure. Raw materials, construction and demolition effects were examined to determine the overall health potential impact.

The relatively light weight of Senergy EIFS contributed to the lowest health potential impact rating in the production and installation phase. The high health potential impacts of stucco and brick are attributed to heavy material use, and specifically to the amount of cement they require.

All three alternatives were similar in the use phase, because the impacts of maintenance requirements were not significantly different.

In the disposal phase, the greatest health potential risk is from diesel fuel emissions that occur during transportation of materials to landfill. In this phase brick used the most fuel, followed by stucco. Lightweight EIFS created the lowest impact.

6. **Occupational illnesses and accidents**
Analyzing risk potential includes the probability of transportation accidents, occupational illnesses and diseases, construction accidents, and similar factors over the lifecycle of the building.

Increased risk factors are associated with alternatives requiring larger quantities of material and higher degrees of construction and maintenance activities. Senergy EIFS provided the lowest risk potential. Brick defines the highest risk alternative among the three systems that were evaluated.

Conclusions

When selecting wall cladding assemblies for nonresidential construction, architects and building owners should be aware of the lifecycle environmental and cost implications of their choices. Systems with high eco-efficiency offer benefits to the environment and to building owners.

Senergy EIFS provide lower lifecycle cost and a reduced environmental impact compared to brick or stucco wall assemblies.

Architects and building owners can contribute to environmental preservation while controlling building lifecycle costs by selecting Senergy EIFS wall claddings.

For more information about this study and BASF EIFS, please visit www.wallsystems.basf.com or call 800-221-9255

BASF's Eco-Efficiency Analysis methodology has been validated by TÜV Berlin and NSF International

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