MEASURING THE SAVINGS OF GREEN BUILDING TECHNOLOGIES

A SELECTION OF PROMISING HIGH-ROI GREEN BUILDING TECHNOLOGIES FOR BUILDERS

U.S. Department of Housing and Urban Development | Office of Policy Development and Research

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Elevating the Economics of Green Building Technologies

Prepared for

U.S. Department of Housing and Urban Development
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Prepared by
Larry Handerhan
Intern, Office of Policy Development and Research (PD&R)
U.S. Department of Housing and Development

Special Thanks to:

Raphael Bostic, U.S. Department of Housing and Urban Development
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Introduction: A Window of Opportunity

The economics of green building has never been more topical. Two years after the great recession ended, the building industry is still struggling to recover from restricted credit access and skyrocketing unemployment.[1] After years of free-wheeling boom building, a premium has been placed on cost-savings and affordability has reemerged as a primary concern for builders, homebuyers, housing providers and tenants.

This rise in austerity coincides with a growing concern in the United States over the impact of the built environment on the natural environment. Climate change and increasing energy costs[2] have elevated the oversized role buildings play in energy consumption: existing buildings account for half of all energy consumed in United States.[3] The residential building sector accounted for 22 percent of this total.[4] Increasingly, mainstream consumers value sustainability and suppliers across all markets are responding in their marketing and product design.

In the building industry, growing interest in affordability and sustainability is stimulating realignment of environmental and economic choices interests. Historically, this has been a challenge for the construction industry. This dynamic has obscured the reality that sustainable development can be profitable by definition,[5] and there has never been a better time for the building industry to embrace rapidly evolving technological innovation.

This intent of this document is reframe the environment versus economics dichotomy into a continuum of affordability for both builders and consumers. It seeks to leverage mutually reinforcing goals in recognition that all parties share a responsibility to build stronger, healthier, and richer communities that can withstand future challenges.

Bridging the Gap Between Sustainability and Economics

[1] Bureau of Labor Statistics, "Industries at a Glance: About the Construction Sector" http://www.bls.gov/iag/tgs/iag23.htm

[2] Real energy costs for all building are up by 19 percent in the past 10 years, though down from their peak in 2008. "Buildings Energy Data Book," U.S. Department of Energy. Table 1.2.1.

[3] Architecture 2030, "Problem: The Building Sector." www.architecture2030.org

[4] Buildings Energy Data Book, U.S. Department of Energy. Accessed 1.12 at http://buildingsdatabook.eren.doe.gov/ChapterView.aspx?chap=1

[5] However, it remains important to guard against the generation of profits by externalizing social costs in unsustainable ways.

Experts and advocates have attempted to quantify the benefits of green building since the movement's inception. The U.S. Green Building Council has been a leader in consolidating interest around their LEED Certification system, and the Council's initiatives have to spirited discussions over the "value" of green.[6] More recently, efforts have sought to demonstrate that sustainable homes command and retain higher market value than non-green peers, and have documented significant improvements in valuations.[7]

The federal government has taken an especially active role in measuring the value of sustainable development. In the past, HUD collaborated on several projects that tracked sustainability metrics, notably the Toolbase Technology Inventory and Partnership for Advancing Technology in Housing (PATH).[8] In 2011, HUD's Office of Policy Development and Research quantified the cost saving potential of greening multi-family housing developments,[9] and a forthcoming report will examine the incremental cost and benefit of achieving various threshold levels of the National Green Building Standards. Similarly, the Department of Energy advertises economical green building interventions and weatherization techniques on their Energy Efficiency and Renewable Energy portal.[10] In 2009, the Obama Administration further elevated sustainability concepts and made them more economically accessible through a series of tax incentives and breaks with green components.

Despite these efforts, green building techniques have not reached their market potential, in part because they are still viewed as cost prohibitive. While unfocused promotion and unjustified skepticism are partially to blame, two obstacles the economics of green building particularly difficult. The first is that variance in development contexts makes it nearly impossible to broadly but accurately estimate savings from a given intervention. Every project's

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[6] One example of good early scholarship: Kats, Gregory. "Green Building Costs and Financial Benefits" Massachusetts Technology Collaborative (2003) http://www.bouldercolorado.gov/files/commercial_green_building_costs_and_benefits_-_kats_2003.pdf

[7] Two good examples are: Eichholz, Kok, & Quigley. "The Economics of Green Building." (2011) http://cbey.research.yale.edu/uploads/Environmental%20Economics%20Seminar/EKQ%20082010%20JMQ%20%282%29.pdf & Schweitzer, Judi. "True-Cost Pricing for Sustainable Development: Finding the real bottom-line in sustainability." (2009) http://www.costar.com/josre/pdfs/Green-JOSRE-True-Cost-Pricing-For-Sustainable%20Development-Finding-Real-Bottom-Line-Sustainability-Schweitzer.pdf

[8] ToolBase Tech Inventory: http://www.toolbase.org/TechInventory/ViewAll.aspx. For a description of PATH, see http://www.huduser.org/about/pdr_path.html.

[9] HUD PD&R, "Quantifying Energy Efficiency in Multifamily Rental Housing." Evidence Matters, Summer 2011. http://www.huduser.org/portal/periodicals/em/summer11/highlight1.html

10 Department of Energy, "Energy Efficiency and Renewable Energy Portal." www.eere.energy.gov.

bottom line is determined by geographic, spatial, political, and regulatory factors.[11] This is intuitive – no one would assert that solar panels work the same in Phoenix, AZ and Phoenix, MI. However, the inability to offer credible and widely applicable benefit projections has understandably fueled skepticism and moderated adoption.

The second obstacle obscuring the benefit of green building is the split-incentive dilemma: benefits come in the form of energy savings for the end-user (the homeowner) while the associated costs are incurred by the initial investor (the developer or builder). Until builders and developers can identify how they benefit directly from sustainable development (or persuasively articulate value for their customers), they have little incentive to deviate from more conventional paths. This is also an obstacle to incremental adaptation from non-green builders. Both these obstacles are formidable but not insurmountable: technologies like oriented strand board (OSB) and compact fluorescent light bulbs (CFLs) have penetrated the market in convincing ways.[12] However, to scale this to the innumerable other technologies that deliver overall utility will require a renewed focus on how costs and benefits are quantified.

A Matrix to Address Gaps and Facilitate Conversation

The following matrix addresses each of these obstacles in narrow but targeted ways. It highlights 10 proven and affordable green building technologies that have not reached full market penetration despite demonstrated economic benefits. In an attempt to overcome cost skepticism, these entries have a track record of providing savings, are affordable across building types and scales, and are viable in diverse climates. While the products have applicability for both multi-family and single-family development, the matrix relies on economic indicators that estimate benefits for single-family residences. Many of the techniques are also relevant to both new construction and retrofits. In an attempt to reconcile the split-incentive dilemma, the matrix highlights any up-front savings for builders as well as life-cycle energy efficiency savings for residents.

[11] A special thanks to Judi Schweitzer of Schweitzer + Associates for first articulating this point to the author.
[12] OSB penetrated the market because it has the same performance at cheaper costs. CFLs don't enjoy the same cost advantage, but ultimately were adopted for their long-range savings. CFLs penetrated the commercial market more easily because the longer lives of the lamps dramatically reduced the labor costs associated with replacing burned-out lamps. This matrix highlights products that match each of these scenarios.

The matrix is organized into four categories: Building Envelope, HVAC, Management and Use, and Water. Each product features a brief description for general reference, but comprehensive technical overviews are addressed by the resources highlighted in the "Additional Information" section.[13] The economic metrics were selected to present a consolidated economic lens for each technology. The metrics selected represent builder benefits (installation savings and market savings, where available) as well as consumer benefits (operational savings). Estimates of Five Year Return-on-investment (ROI) and Net Present Value seek to close a persistent gap in knowledge of long term projected savings, enabling builders to account for these savings in their cost calculations and explain that accounting to their clients. Additionally, the matrix incorporates qualitative durability notes to further elaborate on the benefits to all parties involved.

This document is not intended to be a comprehensive exercise in quantifying green building strategies or elevating every high-ROI product on the market. Instead, it is a simple, accessible, cogent tool to educate and motivate builders about the nuanced economics of green building. It seeks to introduce a menu of green building technologies to *builders* who might one day be *green builders*. It also seeks to push sustainability advocates to establish and codify better evaluation metrics. In sum, it should serve as a starting point to discuss why the building community has struggled to reconcile the environment and the bottom line.

[13] All economic information come from the sources listed in the "Additional Information" section unless otherwise noted.

1: Framing: Optimum Value Engineering (OVE)

Product Category	Description	Estimated Savings	Additional Information
Building Envelope	A series of framing strategies that includes increasing stud, floor joint, and rafter spacing, eliminating some headers, and using two-stud corner framing and inexpensive drywall clips. ✓Eliminates cold spots. ✓Improves energy efficiency. Note: OVE is cheaper to install than conventional framing because of lumber and labor savings	Installation savings: $1.05/sq ft Operational savings: $.15/sq ft/year Market savings: N/A Five Year ROI: $1.74/sq ft. Immediate payback (assumes 3% discount rate) Net Present Value: $3.99 (assumes 3% discount rate). Durability: Reduces potential for mold. Life cycle of 30 years.	Toolbase.org Fact Sheet DOE Energy Savers

2: Insulating Concrete Forms (ICFs)

Product Category	Description	Estimated Savings	Additional Information
Building Envelope	Foam forms filled with reinforced concrete. Blocks or panels are stacked to form walls and filled. ✓Enhances R-value and reduces air infiltration. ✓Increases durability and leads to energy efficiency.	Installation savings: -$6.90/sq ft Operational savings: $0.13/sq ft/year Market savings: N/A Five Year ROI: -$6.30/sq ft (assumes 3% discount rate) Net Present Value: -$4.35 (assumes 3% discount rate). Durability: Rot resistant and less attractive to termites. Safer in natural disasters. Life cycle of 30 years.	Toolbase.org Tech Specs DOE Energy Savers Insulating Concrete Form Association

3. Spray Foam Insulation

Product Category	Description	Estimated Savings	Additional Information
Building Envelope	Alternative to traditional batt insulation. Is sprayed into wall	Installation savings: -$2.25/sq ft	Toolbase.org Tech Inventory

	cavities and expands to fill all pockets of space. ✓Twice the R-value of traditional insulation ✓Environmentally friendly (no HCFCs) ✓Enhances home comfort and reduces moisture and mold.	Operational savings: Assumed to be the same as ICFs and SIPs. $0.13/sq ft/year Market savings: N/A Five Year ROI: -$1.65/sq ft (assumes 3% discount rate) Net Present Value: $0.30 (assumes 3% discount rate). Durability: N/A. Life cycle of 30 years.	Sprayfoam.com

4. Structural Insulated Panels (SIP)

Product Category	Description	Estimated Savings	Additional Information
Building Envelop	Replacement for conventional wall and roof framing. Panels consist of a thick layer of foam between two layers of oriented strand board (OSB), plywood or fiber cement. Prefabricated by manufacturer and shipped to site. ✓Enhances R-value and reduces air infiltration. ✓Reduces lumber requirement. ✓Can come with variety of finished surfaces.	Installation savings: -$2.60/sq ft Operational savings: $0.13/sq ft/year Market savings: N/A Five Year ROI: -$2.00/sq ft (assumes 3% discount rate) Net Present Value : -$0.05 (assumes 3% discount rate). Durability: High resistance to wind; require less maintenance. Life cycle of 30 years.	Toolbase Tech Specs

5. Aerosol Duct Sealing

Product Category	Description	Estimated Savings	Additional Information
HVAC	Method of forcing vinyl acetate adhesive particles into heating and cooling duct systems to plug leaks. (Also consider polypropylene take-off collars to supplement.) ✓Prevents efficiency loss from escaped heating and cooling. ✓Easier to install than conventional sealing methods.	Installation savings: -$0.50/sq ft Operational savings: $0.10/sq ft/year Market savings: N/A Five Year ROI: $0.04/sq ft/year (assumes 3% discount rate) Net Present Value: $0.35/sq ft (assumes 3% discount rate). Durability: Life cycle of 10 years.	Toolbase.org Tech Inventory DOE EETD 10 Year Recap

6. Install HVAC & Ductwork in Conditioned Space

Product Category	Description	Estimated Savings	Additional Information
HVAC	Instead of running ductwork through attics, crawlspaces, and garages, this strategy places ductwork in conditioned spaces like bulkheads, soffits, and tray ceilings. This prevents energy loss from leakage and dramatic temperature variances. ✓Energy efficient ✓Reduces likelihood of condensation / moisture. ✓Widespread application	Installation savings: -$0.20/sq ft Operational savings: $0.02/sq ft/year Market savings: Market for improved indoor comfort. Five Year ROI: -$0.11/sq ft (assumes 3% discount rate) Net Present Value: $0.19 (assumes 3% discount rate). Durability: Less likely to have moisture problems. Life cycle of 30 years.	Toolbase.org Tech Specs Toolbase.org Tech Inventory

7. Customized HVAC Sizing

Product Category	Description	Estimated Savings	Additional Information
HVAC	Using house plans, a contractor can measure specific size needed for HVAC equipment rather than using rule of thumb. Leads to smaller, cheaper systems. ✓Energy efficient ✓Durable. ✓Improves indoor air quality.	Installation savings: -$0.17/sq ft Operational savings: $0.05/sq ft/year Market savings: Market for improved indoor comfort. Five Year ROI: $0.06/sq ft Immediate payback. (assumes 3% discount rate) Net Present Value: $0.57/sq ft (assumes 3% discount rate). Durability: Reduction in short-cycling means longer life span. Life cycle of 20 years.	Toolbase.org Tech Inventory Air Conditioning Contractors of America (ACCA) Quality Installation Specification

8. Programmable Thermostats

Product Category	Description	Estimated Savings	Additional Information
Management and Use	Save energy by permitting occupants to set temperatures according to use. ✓Reduces energy consumption	Installation savings: -$0.03/sq ft Operational savings: $0.15/sq ft/year Market savings: N/A	Toolbase.org Tech Inventory ENERGY STAR Products

	by not conditioning house when unoccupied. ✓Easy to implement.	Five Year ROI: $0.66/sq ft. Payback within less than a year. (assumes 3% discount rate) Net Present Value : $1.25 (assumes 3% discount rate). Durability: N/A. Life cycle of 10 years.	

9. Air admittance valves (AAVs)

Product Category	Description	Estimated Savings	Additional Information
Water	Pressure-activated one-way mechanical vents used in plumbing system to eliminate conventional pipe venting and roof penetrations. ✓Greater flexibility in laying out rooms ✓Easy to install. ✓Applicable to new construction & retrofit.	Installation savings: $0.21/sq ft Operational savings: $0.00/sq ft/year Market savings: N/A Five Year ROI: $0.21/sq ft. Immediate payback.(assumes 3% discount rate) Net Present Value : $0.21 (assumes 3% discount rate). Durability: Requires no maintenance. Life cycle of 30 years.	Toolbase.org Tech Inventory

10. Polyethylene plastic piping (PEX)

Product Category	Description	Estimated Savings	Additional Information
Water	Flexible cross-linked piping applicable to water, drainage, fuel gas, conduit and plumbing / heating. Can be snaked through walls like electrical wiring. ✓Durable, resistant to corrosion. ✓ No Volatile organic compounds (VOCs); recyclable. ✓Applicable to new construction & retrofit.	Installation savings: $0.16/sq ft Operational savings: Difficult to quantify. Piping provides some insulation value. Reduced pipe diameter results in water savings from reduced hot water waste. Market savings: N/A Five Year ROI: $0.16/sq ft, Immediate payback. (assumes 3% discount rate) Net Present Value: $0.16 (assumes 3% discount rate). Durability: Fewer joints and resistant to corrosion means less maintenance costs. Life cycle of 30 years.	Toolbase Tech Specs Pexinfo.com

Note: Because the available cost data is often drawn from early adoptions, later experiences may show lower initial costs and greater savings.

Addendum: Methodology

GENERAL QUALIFICATIONS

This document highlights 10 proven and affordable green building technologies that have not reached full market penetration despite demonstrated economic benefits. All entries have a track record of providing savings, are affordable across building types and scales, and are viable in diverse climates.

Inclusion in this document was based on the following characteristics:

- **Proven Environmental Impact:** Technologies were only considered if they were environmentally friendly, often by lowering overall energy use or taking advantage of environmentally sensitive materials.
- **Demonstrated Cost Effectiveness**: Each technology selected had to result in some savings to the builder or home-owner in the form of energy efficiency, durability, and/or expected return-on-investment.
- **Relatively Low Cost**: Technologies are intended for relatively easy and cost-effective installation: effective but cost-prohibitive products like solar panels were not considered for this matrix.
- **Not at Full Market Potential**: Since this document is intended to encourage higher use among builders, pervasive industry practices like LED Light Bulbs are not included.

SOURCES

Most of the information on technologies comes from the following sources: ToolBase Tech Inventory, The Department of Energy's Energy Efficiency and Renewable Energy Portal (EERE), and the Department of Housing and Urban Development's Partnership for Advancing Technology in Housing (PATH).

METRICS

Installation Savings:

$$Green\ Material\ \&\ Installation\ Cost, \frac{\$}{sf} - \ Standard\ Material\ \&\ Installation\ Cost, \frac{\$}{sf} = \ Installation\ Savings, \frac{\$}{sf}$$

Operational Savings: Data extrapolated from case studies (when available).

$$Energy\ Costs\ of\ Green\ Technology, \frac{\$}{\frac{sf}{yr}} - Energy\ Costs\ of\ Standard\ Technology, \frac{\$}{\frac{sf}{yr}} = Operational\ Savings, \frac{\$}{\frac{sf}{yr}}$$

Market Savings:
Pertains to technologies that have had a proven ability to increase market value at time of sale. Data extrapolated from case studies (when available).

Five Year Return on Investment:
To examine the ROI over a relatively short term may help to convince a homebuyer to include a green product or process in a new home that the purchaser wouldn't expect to remain in for the service life of the structure.

Note: In some cases, the proposed approach is less expensive than the conventional approach and the initial ROI is favorable as the technology has an immediate payback.

$$Installation\ Savings - Annual\ Savings\ \times \frac{\{([1+i]^5) - 1\}}{\{i(1+i)^5\}} = Five\ Year\ Present\ Value$$

Net Present Value:
For the net present value determination, the NPV is determined based on the expected service life of the product used. For these estimates, that was capped at 30 years for the longest lived products, regardless of their expected service life.

$$Installation\ Savings - Annual\ Savings\ \times \frac{\{([1+i]^{Life\ Cycle}) - 1\}}{\{i(1+i)^{Life\ Cycle}\}} = Net\ Present\ Value$$

Qualitative Measurement:
Durability: Enhanced durability is not easily quantifiable but is a tenet of high-quality, sustainable builder that adds value for consumers and could be a selling point for the builder. Also includes projected life cycle.
Other Product-Specific Non-Economic Advantages: The description box also highlights any potentially attractive advantages that do not fit into the above categories.