GREEN BUILDING IMPACT REPORT 2008

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Executive Summary

Green buildings, as represented by the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System, are an undisputed market success. In the eight years since the launch of LEED, green has firmly established itself among mainstream leaders in the building sector, representing tens of billions of dollars in value put in place and materials sales.

LEED was created to reduce the environmental impacts of the built environment, but so far no comprehensive evaluation of the overall impact of LEED has been conducted. Until now.

This *Green Building Impact Report* is the first-ever integrated assessment of the land, water, energy, material and indoor environmental impacts of the LEED for New Construction (LEED NC), Core & Shell (LEED CS) and Existing Building Operations and Maintenance (LEED EBOM) standards. (We did not include Commercial Interiors due to concerns about double-counting, which we hope to have resolved before the release of next year's report.)

In this report we attempt to answer whether commercial green buildings live up to their name — that is, that they are engendering demonstrable environmental improvement.

Our findings are both encouraging and cautionary. Overall, we believe that LEED buildings are making a major impact in reducing the overall environmental footprint of individual structures. However, significant additional progress is possible and indeed necessary on both the individual building level and in terms of market penetration if LEED is to contribute in a meaningful way to reducing the environmental footprint of buildings in the U.S. and worldwide.

Market Summary

To date, our calculations indicate that LEED Certified projects represent more than 6% of new commercial construction, but there has been an astronomical ramp-up in the past year of new project registrations, with new construction sector penetrations approaching a whopping 40%. On average, it takes approximately two years from Registration to Certification, with an attrition rate of 25% to 30%.

LEED NC continues to lead the way, with Certified projects representing 5.8% of new construction starts and new registrations representing approximately 30% of the market.

Registrations of Core & Shell projects have ramped up considerably in the past two years, now approaching 12% of new commercial starts, though they lag significantly behind LEED NC in submarket share and absolute terms. Certified LEED CS projects represent only about 0.5% of new construction starts.

Although introduced three years later, the floor area of new registrations in LEED EBOM has nearly caught up to that of LEED NC, though as a percent of the annual addressable market, certifications remain insignificant.

Environmental Impacts

Non-residential construction, the focus of our report, represents about 40% of the environmental burden of buildings. The environmental benefits of LEED are multifaceted and hard to generalize, so we present the topline findings here and in more detail in the body of the report:

Land Use. We estimate that between efficient location and the myriad of alternative transportation options supported by LEED, nearly 400 million vehicle miles traveled have been avoided by the occupants of LEED buildings. This grows to more than 4 billion vehicle miles by 2020.

Water. We expect water savings from LEED commercial buildings to grow to more than 7% of all non-residential water use by 2020. The equivalent of 2008 LEED water savings would fill enough 32-ounce bottles to circle the Earth 300 times.

Non-residential construction, the focus of our report, represents about 40% of the environmental burden of buildings.

Energy. LEED saves energy on many different levels, including energy related to operations, commuting, water treatment and the lower energy embodied within materials. In operational energy terms, LEED buildings consume approximately 25% less on average than comparable commercial buildings. By 2020, these energy savings amount to more than 48.7 million tons of coal equivalent each year, representing approximately 78 million tons of carbon dioxide (CO_2) avoided emissions.

Materials and Resources. LEED has helped spur an entire industry in green building materials. Certified projects to date have specified a total of more than $10 billion of green materials, which could grow to a cumulative amount exceeding $100 billion by 2020.

Indoor Environmental Quality. We believe that indoor environmental quality is the most important contributor to the productivity attributes of LEED. We conservatively calculated that companies with employees working in LEED buildings realized annual productivity gains exceeding $170 million resulting from improved indoor environmental quality, a number that will grow to nearly $2 billion of annual productivity improvements by 2020.

Details on the methodological approach behind this study can be found in the appendix, starting on page 18.

What's Next?

Our 2009 *Green Building Impact Report* will include the impact of LEED buildings overseas as the growth of LEED's new construction standards shifts beyond the U.S. market, with fast-growing development in emerging economies.

Several new non-residential LEED standards have recently been released, such as those for schools and retail establishments, and the 2009 report will evaluate these impacts as well. It will also include the eco-footprint of residential construction, the built environment's largest source of environmental impacts.

LEED Market Trends

The current economic situation coupled with increased stringency in the LEED requirements will contribute to an expected slowdown.

In 2007, LEED Registrations and Certifications doubled compared to the previous six years and in 2008 they doubled those of the previous seven years. LEED NC Registrations and Certifications continued their growth, but not at the doubling rate. The Core and Shell (LEED CS) system grew 13-fold compared with 2006, while LEED for Existing Buildings Operations & Maintenance (LEED EBOM) expanded nearly 20-fold.

Obviously, these growth rates are not sustainable. The current economic situation coupled with increased stringency in the LEED requirements will contribute to an expected slowdown. In the U.S. — the focus of this report — we expect a flattening of the growth rate or even a decrease in the new construction markets, both of which will reflect a slight decrease in general LEED NC and LEED CS projects and rapid growth in the Schools and Retail markets. We do expect, and indeed hope, that the growth in LEED EBOM continues, given the relative magnitude of the existing building stock compared with the size of new additions to floor space.

Going forward, we anticipate that LEED's growth will flatten relative to the market as it reaches the expected saturation point for the level of stringency the market is able to handle. Even though the growth *rate* flattens, in absolute terms we believe the amount of floor area being added to the system will continue to grow. Although not explicitly covered in this year's report, we anticipate LEED's growth overseas will continue to expand and may even exceed new floor area added in the U.S. as early as next year.

Cumulative Square Footage of LEED Certifications
(in millions of square feet)

	2008	2015	2020
Certified LEED NC	240	1,720	3,130
"Built-to" LEED NC	223	1,240	1,700
Certified LEED CS	17	640	1,300
"Built-to" LEED CS	37	630	910
Certified LEED EB	38	3,260	6,670
"Built-to" LEED EB	13	1,450	2,340

Land Use Impacts

More Reclaimed, Fewer Drains and Automobiles

LEED addresses impacts to the land in a wide variety of ways, which can be summarized in three principal categories: (1) Location efficiency, (2) Site protection & restoration and (3) Site performance.

Unlike most of the other impact categories where benefits of LEED are directly related to project floor area, site impacts relate to the number of projects. Thus, our assessment of progress to date is based on actual project figures from USGBC. Our projections of the number of projects derive from the growth in floor space and the average size of LEED projects.

We did not evaluate site impacts for LEED EBOM in this study. These impacts relate to pesticide use and other measures that are difficult to quantify. We will attempt to evaluate this next year.

Location Efficiency: We chose reductions in vehicle miles traveled (VMT) to illustrate the benefits of location efficiency and alternative transportation methods promoted by LEED. According to research by the Natural Resources Defense Council (NRDC), location-efficient development results in a 30% reduction in VMT. Overall, we estimate a reduction of nearly 400 million VMT annually because of current LEED projects. Our projections indicate that roughly 2.5 billion VMT will be reduced each year by 2015, which grows to more than 4.2 billion VMT by 2020.

Overall, we estimate a reduction of nearly 400 million vehicle miles traveled annually occurs because of current LEED projects.

These reductions are the equivalent of taking nearly 32,000 vehicles off the road and saving more than 15 million gallons of fuel to date, all of which has eliminated nearly 4 million tons of CO_2. These figures will grow to 350,000 vehicle-equivalents and more than 172 million gallons of fuel saved by 2020, avoiding more than 40 million tons of CO_2, as well as more than 16,000 tons of air pollutants like carbon monoxide, NOx and hydrocarbons, each year.

Land-Use Impacts Summary

	2008	2015	2020
Savings in Vehicle Miles Traveled	380,000,000	2,490,000,000	4,230,000,000
Number of Vehicles Reduced	32,000	207,500	352,500
Gallons of Gasoline Reduced	15,500,000	101,600,000	172,700,000

Emissions Reductions
(in tons)

	2008	2015	2020
Hydrocarbons	30	210	350
CO	1,400	9,300	15,800
NOx	46	300	510
Particulates	4	27	47
CO2	3,800,000	24,900,000	42,300,000

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For each storm producing greater than three-quarters of an inch of rainfall, LEED requirements avoid or treat approximately 100 million gallons of "toxic flush."

Site Protection: Our calculations show that LEED measures have to date prevented nearly 500,000 tons of soil erosion and will avoid between 4 million and 6 million tons of soil loss by 2015 to 2020. In addition, more than 5,000 acres of sensitive land have been left undeveloped, an amount that will grow to more than 70,000 acres by 2020.

LEED has resulted in an estimated 250 acres of brownfield reclamation, which we expect to grow to more than 3,000 acres by 2020. Other site restoration activities have created more than 400 acres of additional open space in urban areas to date, and will reach an anticipated level of 5,500 acres in the next 12 years.

Site "Performance": Stormwater runoff and urban heat islands are two important elements of site performance evaluated by LEED. We calculate that for each storm producing greater than three-quarters of an inch of rainfall, LEED stormwater prevention and treatment requirements avoid or treat approximately 100 million gallons of "toxic flush" — rain that rinses the chemical and particulate deposition from the sky into sewers and eventually, in most cases, to rivers and oceans. By 2020, this volume treated grows to approximately 1 billion gallons per storm event.

About 5,000 acres of land and rooftops have implemented measures to reduce urban heat islands. We expect more than 35,000 acres of similar measures by 2015 and 50,000 by 2020.

Water Efficiency Impacts

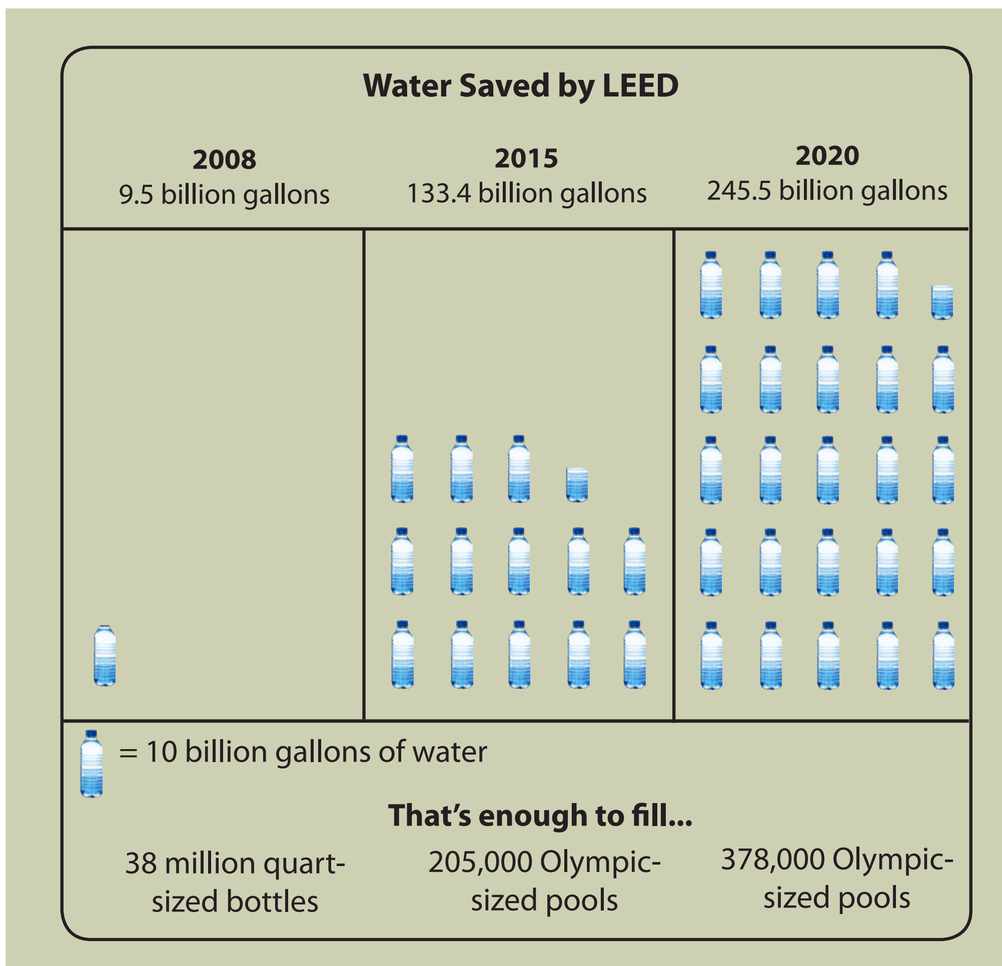
Far More Than a Drop in the Bucket

We expect savings of 46.5 billion gallons of wastewater by 2015 and 86.2 billion gallons saved by 2020, representing 1.7% and 3.1% reductions in annual wastewater generation, respectively.

Water use in buildings represents the vast majority of the world's consumption of potable water. In the U.S., which has among the world's highest access to treated drinking water, only 10% of all fresh water is treated for human use. More than 80% of potable water flows through buildings, thus protecting this vital resource depends on improving the ways in which water is used in buildings.

LEED addresses the need for efficient and reduced water use in buildings foremost through conservation. Plumbing systems, cooling towers and landscaping are the main areas where green design can effectively minimize a building's demand for treated water. Devices and practices as simple and cost-friendly as better plumbing fixtures and appliances or time-use irrigation schedules go a long way in preventing "soaked" buildings. Since the inception of LEED, more than half of New Construction and Core & Shell projects have delivered at least a 30% water reduction, with 20% savings from Existing Buildings Operations & Maintenance. Almost 90% of NC and CS projects have achieved 50% reduction in water use for landscaping.

However, saving water requires more than merely reducing the consumption of treated water. On-site treatment strategies promoted by LEED aim to limit building-generated wastewater. Though it is presently unfeasible to expect all future projects to adopt graywater recycling systems, LEED buildings have



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Water Efficiency and Treatment Impacts

	Units	Impact to Date	Projected Impact 2015	Projected Impact 2020
Total LEED floor space	Million Square Feet	570	8,900	16,000
Plumbing Water Savings	Million Gallons	1,260	24,000	45,000
Landscape Water Savings	Million Gallons	5,400	65,200	118,100
Cooling Tower Water Savings	Million Gallons	2,800	44,100	82,200
Total	Million Gallons	9,500	133,000	245,500
Annual Non-Residential Water Use	Percent	.3	4.1	7.5
Wastewater Reduction				
Total	Million Gallons	3,300	46,500	86,200
Annual Wastewater Reduction	Percent	.1	1.7	3.1

already made impressive strides in reducing the production of wastewater. To date, one out of five Certified New Construction projects features innovative water technologies such as stormwater or graywater collection and re-use systems.

Plumbing Fixture and Cooling Tower Water Use Reductions: Estimated annual savings from plumbing fixture and cooling tower efficiency currently amount to nearly 4.1 billion gallons. We expect savings to skyrocket in the next few years, reaching 46.5 billion gallons of water saved by 2015, and nearly doubling to 86.7 billion gallons by 2020.

Landscaping Water Reductions: To date, more than 5.4 billion gallons of water have been saved through landscaping water reductions alone. We foresee landscaping water savings exceeding 65 billion gallons by 2015, and 118 billion gallons by 2020.

Aggregate Water Savings: Total water savings from combined usage of plumbing, landscaping and cooling towers as of 2008 are 9.5 billion gallons, about 0.3% of annual non-residential water use. By 2015, with LEED floor area approaching 9 billion square feet, this figure is expected to exceed 133 billion gallons annually, or 4.1% of non-residential water, an increase of more than 1,000%. This number will nearly double by 2020, reaching 245 billion gallons of saved water, which represents 7.5% savings of annual non-residential water use.

Wastewater Reductions: Based on the fraction of LEED projects pursuing innovative wastewater treatment, we found that annual reductions of 3.3 billion gallons of wastewater releases have been achieved to date, a 0.1% reduction in annual wastewater generation. This figure is highly conservative, since it does not include the reductions in water use from plumbing and cooling tower savings, nor does it include savings in excess of LEED requirements.

We expect savings of 46.5 billion gallons of wastewater by 2015 and 86.2 billion gallons saved by 2020. These figures represent, respectively, 1.7% and 3.1% reductions in annual wastewater generation.

Energy Impacts

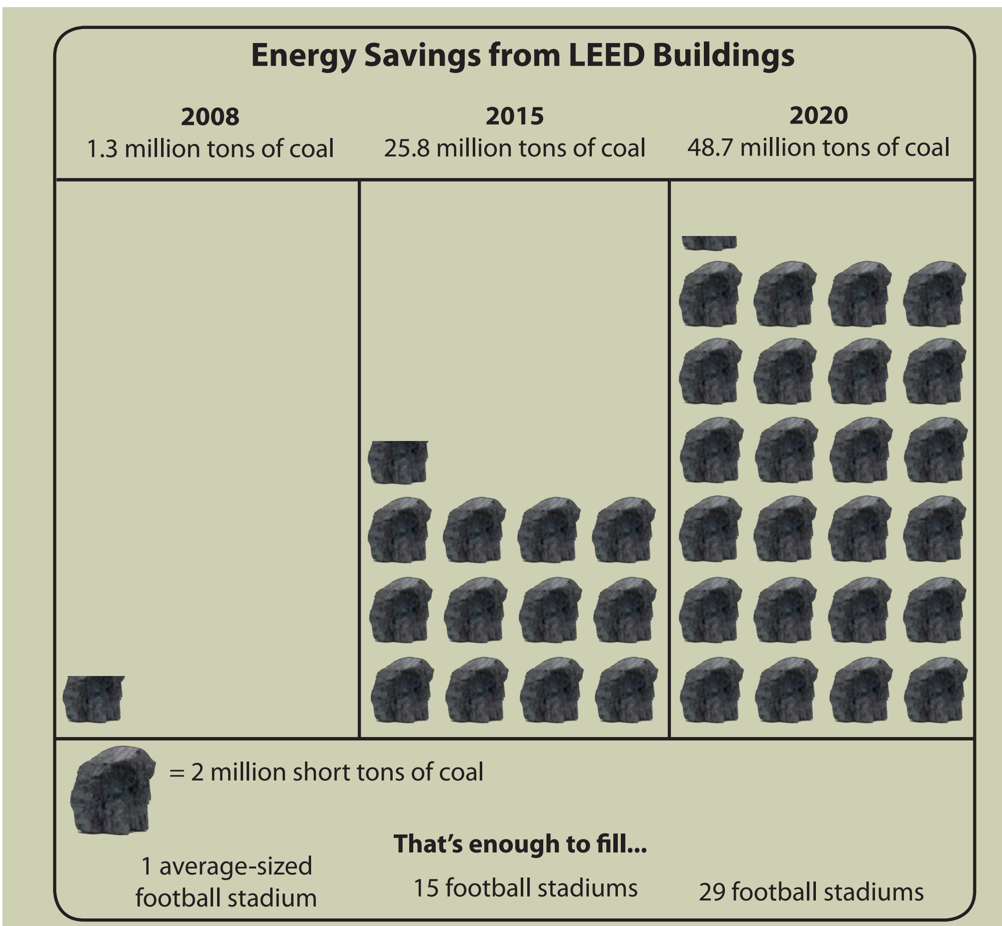
Efficiency + Renewables = Strong Potential

The construction and operation of buildings requires more energy than any other human activity. The International Energy Agency (IEA) estimated in 2006 that buildings used 40% of primary energy consumed globally, accounting for roughly a quarter of the world's greenhouse gas emissions. Commercial buildings comprise one-third of this total. Urbanization trends in developing countries are accelerating the growth of this sector relative to residential buildings, according to the World Business Council on Sustainable Development (WBCSD). Reducing these emissions is therefore a cornerstone intention and responsibility of green building standards and initiatives.

However, energy savings from green buildings remains one of the most important and controversial facets of LEED's environmental benefits.

LEED requires a minimum of 14% energy savings when compared to the American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) commercial energy efficiency standard 90.1-2001 to 2004. Last year, a New Buildings Institute (NBI) report, released at Greenbuild 2007 and updated in 2008, found that LEED buildings in various occupancy categories saved 25% to 30% of measured energy compared to average commercial energy consumption figures reported by the U.S. Department of Energy.

However, the NBI report has been criticized on various grounds, some of which, in our opinion, are valid and others less so. A resolution of these issues, which ultimately is one part substantive, one part philosophical and one part unknowable, is beyond the scope of this report.



We believe that a reasonable goal for the LEED system would be to shoot for an absolute reduction in national commercial energy consumption, or at least zero growth by 2015.

After reviewing the arguments and information on both sides, we believe that energy savings from LEED buildings are real and quantifiable — both in terms of financial savings and resource savings — but are not as large as hoped and definitely require improvement. Key issues to evaluate going forward are the relationship of modeled results to measured results, and better measurement and tracking of buildings' energy consumption over time.

Both of these areas would be significantly resolved by stronger emphasis on the LEED EBOM standard and greater weighting on the measurement and verification elements of LEED, some of which has been adopted for LEED 2009.

Energy Savings: The NBI study reports savings ranging from 25% to 30%, which is consistent with the analysis of LEED Certified project scorecards that we undertook and other field studies of the energy performance of LEED Buildings. (See, for example, "Assessing Green Building Performance: A Post-Occupancy Evaluation of 12 GSA Buildings," GSA Public Buildings Service, June 2008.) In addition, the scorecard tally shows that LEED EBOM projects reduce energy by 37% compared to the baseline Energy Star 60 score used by LEED.

For the 25% energy savings (low-case) scenario, our findings indicated .03 quadrillion Btu (quads) of energy savings to date, which represents 0.14% of U.S. commercial building energy consumption. This represents 1.3 million tons of coal per year, enough to fill an average football stadium.

So long as the adoption of LEED continues to trend upward as our research suggests, this figure is expected to reach 0.52 quads by 2015 and 0.97 quads by 2020, or 2.4% and nearly 4.3%, respectively, of national annual commercial energy use. The 30% (high-case) savings scenario revealed more or less similar results to date. Using high-end measurements, we find it reasonable to expect energy savings of 2.6% and close to 4.6% of national annual commercial energy use by 2015 and 2020, respectively. The coal represented by these energy savings would fill every professional football stadium in the U.S.

Unfortunately, this level of savings is not sufficient to reduce absolute energy demand from commercial buildings nationwide: growth in floor area is greater than the LEED-driven energy-use reduction, which results in continuing increases in total energy use. We believe that a reasonable goal for the LEED system would be to shoot for an *absolute* reduction in national commercial energy consumption, or at least zero growth by 2015, or even 2010.

Renewable Energy Impact: Because the implementation of renewable energy is a crucial objective for reducing ever-more significant environmental impact, we felt it important to measure the energy from renewable sources used by LEED buildings so far. Though relatively low to date, the percentage of renewably derived energy associated with green buildings has considerable growth potential, both in the form of on-site generation of renewable energy as well as (in the case of LEED EBOM, in particular) using clean sources of energy to power buildings through renewable energy certificates (RECs) and direct purchases of renewable energy.

We forecast that green building electricity from renewable sources will exceed 32.5 billion kWh by 2015, approaching 59 billion kWh by 2020.

Renewable Energy Generated by LEED Buildings

	2008	2015	2020
Total LEED-generated renewable electricity (in billions of kilowatt hours)	1.63	32.52	58.97
As a percentage of total non-residential electricity use	0.1%	2.0%	3.3%
Equivalent number of households powered	153,000	3,050,000	5,530,000

From our findings, we concluded that LEED buildings have purchased or generated 1.63 billion kilowatt-hours (kWh) of total renewable electricity to date, representing 0.1% of annual nationwide non-residential electricity — a seemingly small amount, but enough to power more than 150,000 households.

Commensurate with expected continued green building growth, we forecast that green building electricity from renewable sources will exceed 32.5 billion kWh by 2015, approaching 59 billion kWh by 2020. These numbers represent 2% and 3.3%, respectively, of forecasted annual U.S. non-residential electricity, equivalent to the energy used by more than 5 million homes.

Emissions Reductions: Between the CO_2 reductions from building energy savings and the zero air pollution emissions from renewable electricity, the LEED renewables picture is somewhat brighter than energy savings on a percentage basis. In total, we calculate that LEED buildings have reduced CO_2 emissions by 7 million tons to date, a number we estimate will cumulatively grow to more than 700 million tons by 2020. Annually, these reductions grow from 3.5 million tons of CO_2 in 2008 to more than 115 million tons per year in 2020.

Financial Savings from Commissioning and Monitoring & Verification (M&V): One of LEED's most radical changes to the status quo of design and construction was the mandatory requirement to commission its projects. At its core, commissioning ensures that the owner's vision is designed and built properly. This process involves design review, construction supervision and equipment functional testing and handover.

We find that LEED commissioning requirements have resulted in significant financial savings to LEED buildings. Lawrence Berkeley National Laboratory (LBNL) research shows that commissioning has both energy and non-energy benefits. Since we assume the energy benefits are captured in the efficiency savings calculations, we wanted to quantify the non-energy benefits described by LBNL.

Our results show that commissioning and M&V activities have realized over $600 million in non-energy economic savings in LEED NC, LEED CS, and LEED EBOM buildings. The savings from commissioning and M&V are expected to grow exponentially in the next several years, with the potential to exceed $5 billion by 2015 and nearly doubling to just under $10 billion by 2020.

Materials Impacts

More Reducing, Reusing, and Recycling

Local and recycled-content building materials for LEED buildings represented about $10.5 billion in cumulative spending through 2008, growing more than tenfold to $110 billion by 2020.

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A real assessment of the environmental impacts of materials is still somewhat *terra incognito* in the green building movement. It is one of the most complex areas to evaluate from an impacts perspective and essentially impossible to determine "savings."

Some things can be counted, such as the volume of materials diverted from the landfill and the approximate embodied energy of materials reused. The data for LEED EBOM are still weak in this area, so we will focus our analysis on the impacts from LEED NC and LEED CS.

Building & Materials Reuse: Reusing buildings is becoming more common for LEED certified projects, with more than 12% of projects reporting major reuse of buildings and interior components. In square footage terms (based on LEED NC only), this totals 37 million square feet to date. We forecast that this figure will exceed 400 million square feet by 2020.

Materials reuse is still somewhat lagging in LEED projects as it has taken time for adequate sources of quality reused material to develop and reach the market. We evaluated the environmental impacts of materials reuse in terms of savings in embodied energy, concluding that materials reuse in LEED buildings has saved the equivalent of 70,000 barrels of oil, a number that will grow to nearly 800,000 barrels equivalent by 2020.

Construction & Demolition Waste: Aggregate data show that nearly 60% of the C&D waste generated by LEED projects is diverted. Between the Certified and "Built to LEED" projects, we estimate that LEED buildings to date have recycled or reused a cumulative total of 24 million tons of waste. These diversion figures mushroom to 200 million tons in 2015 and 325 million tons in 2020. (See Appendix for the "Built to LEED" project definition.)

Green Materials Impacts: The varied use of materials and the lack of good data make an evaluation of materials' other impacts difficult. For this reason, we will follow LEED's lead by evaluating several materials categories on a dollar basis.

Based on average materials costs, local and recycled-content building materials for LEED Certified buildings represented approximately $10.5 billion in cumulative spending through 2008. By 2020, total spending in this area is expected to grow more than tenfold to almost $110 billion. We should note that these figures are conservative because they do not include the value of materials that are evaluated based on their indoor environmental quality characteristics, such as low-VOC paints and nontoxic adhesives.

As LEED moves toward a more normalized lifecycle assessment basis for evaluating the onsite, upstream and downstream impacts of materials use in buildings, we will be better able to evaluate these impacts comprehensively.

Certified Wood: Based on average non-residential wood use estimates and the penetration of the certified wood credit in LEED, our analysis shows that to date more than 100 million board-feet equivalent of Forest Stewardship Council certified wood has been installed in LEED projects. If current penetration rates continue, this utilization will reach nearly 1.3 billion board feet by 2020.

Indoor Environmental Quality

Productivity Savings Are a Breath of Fresh Air

A major tenet of green building design is the improvement of indoor environmental quality. Providing brighter, better-ventilated spaces not only benefits the environment — by reducing pollutant emissions in workspaces through the use of non-toxic cleaning chemicals, paints, sealants and furniture — but also improves the productivity of workers in that space. For that reason, we felt it critical to determine the impact LEED buildings have on indoor environmental quality as measured through improvements in worker productivity.

Studies have uncovered productivity increases from green building measures ranging from 1% in manufacturing to more than 25% in a law office.

While operational savings are important, the financial benefits in LEED are achieved principally through the enhancement of employee productivity. Salaries represent approximately 90% of the money flow through a building, the rest being amortized construction costs, operations and maintenance, including utilities. Studies in a range of work situations have uncovered productivity increases from green building measures ranging from 1% in manufacturing to more than 25% in a law office. For our estimates of green building benefits from LEED, we assume a conservative range of 1% to 2% productivity increase resulting from the range of the indoor environmental quality measures rewarded by LEED.

Taking an average of the number of employees affected by various features of green buildings, we ascertained that approximately 350,000 employees are currently enjoying improved indoor environments in LEED buildings. Presuming that LEED floor space — particularly LEED EBOM — continues to grow through the next 10 to 15 years, the "green building workforce" is expected to exceed 5 million by 2015, becoming 9 million strong by 2020.

While the "green building workforce" figures are in themselves compelling, the rubber meets the road from a benefits perspective in terms of productivity gains. While environmental impacts should not necessarily require economic justification, financial gains need to be demonstrated in order for the market to continue to demand green buildings.

Our analysis suggests a noticeably greener hue of green buildings, namely in the form of monetary savings. We calculated that $120 million to $250 million already has been saved through productivity gains of the green building workforce. Given continued growth in green buildings, we expect this number to grow significantly in the future: reaching between roughly $1.7 billion and $3.5 billion by 2015, and between nearly $3.2 billion and $6.4 billion by 2020.

Indoor Environmental Quality Impacts of LEED

	2008	2015	2020
No. of Employees Affected by Better Work Environments	350,000	5,020,000	9,010,000
Value of Productivity (High Estimate)	$250,000,000	$3,500,000,000	$6,400,000,000
Value of Productivity (Low Estimate)	$120,000,000	$1,770,000,000	$3,170,000,000

The Big Picture

Can LEED Make a Dent in Climate Change?

LEED buildings are not making enough of a dent in constraining the growth of the building sector's CO_2 emissions. We need much more — and much more quickly — to reduce total emissions.

One reason the U.S. Green Building Council's membership has grown 65% on an annual basis for the last 15 years is a compelling positive vision of the future and an important social mission. The LEED standard has been an important, if not the main, driver of this growth. As we have seen, LEED buildings conserve the land, save water and energy, reduce materials impacts and result in better, more productive indoor environments. People participate in the USGBC because they want to make a difference. And they are making that difference, but more needs to be done.

A distinguished group from Sigma Xi, a national organization of top scientists, and the United Nations Foundation published a report for the UN Commission on Sustainable Development in 2007 outlining the steps necessary to "avoid the unmanageable and manage the unavoidable." The findings were pretty Draconian: In order to maintain global carbon dioxide levels below a doubling of pre-industrial levels, CO_2 emissions would need to be reduced by 80% below 2000 levels by 2050. To put it another way, in spite of projected floor space increases of 150%, total sector emissions will need to be only 20% of what they currently are.

This actually may be achievable. If we assume that this 80% reduction were to be spread evenly, then buildings' CO_2 footprint on a per-square-foot basis would need to decline steadily each year by roughly 1.6% — or a total of 14% improvement by 2008. The good news is that LEED buildings are actually quite a bit ahead of in terms of their own performance relative to this goal. (This statement applies to LEED commercial buildings only. We will evaluate LEED for Homes in 2009.)

The bad news is that the *entire building sector* must be hitting these reduction targets. LEED buildings' relatively exemplary performance is not helping to make enough of a dent in constraining the growth of the building sector's CO_2 emissions. We need much more — and much more quickly — to reduce total emissions.

How much more and how much more quickly? This is a complex question both analytically and practically. Our initial analysis shows that by 2010, LEED buildings on average will need to be at least 35% more efficient than today's average buildings and that the LEED EBOM standard will need to penetrate 50% more rapidly than our current projections indicate in order to stay on track. This would accelerate CO_2 emissions reductions from our estimates of 4.5 million tons in 2010 to nearly 7 million tons.

These trends would need to continue aggressively through the forecast period, meaning that efficiency requirements would need to continually improve and penetration continually increase.

Market Transformation: Realistically, LEED cannot do it all by itself. LEED is a vital part of the market transformation process that combines market pull with regulatory push. LEED was designed to lead by improving the performance of the top 25% of buildings and by any measure it has succeeded. Indeed, LEED will need to increase its rate of improvement, but additional measures are needed to support these improvements, as well as support and accelerate the uptake of LEED-like measures in the mass market.

Building codes will need to improve by greater amounts and more frequently.

Market mechanisms in the form of technology incentives and energy prices that reflect true environmental and social costs will also be needed to accomplish these goals. Smart grid technologies should be required in all new buildings and tenant build-outs. To support this, utilities should be allowed by their regulators to significantly ramp up their energy-efficiency incentive programs and institute revenue neutral (or not) sliding scale hook-up fees that reward efficient "grid-smart" buildings with low to no fees, while code-minimum buildings should get socked with hefty fees. Banks and insurance companies must increase their current offerings for green buildings to reflect the lower risks of green buildings, as well as help minimize total extra initial costs of green, which there will be as markets mature. Non-economic sweeteners, such as accelerated permit approval and density bonuses for LEED-certified buildings will also help.

In addition, policymakers will need to be less squeamish about pricing carbon. Since we know with 100% certainty that the only precisely wrong answer is zero, no matter what price they put on carbon, "approximately right" will be better than the precisely wrong price we have now. This *is* a policy decision, since our present 18th-century market structure is not capable of pricing social goods without intervention.

Similarly, building codes will need to improve by greater amounts and more frequently. ASHRAE should expedite the development and adoption of Standard 189 and strongly push its adoption nationwide. The market incentive programs described above will be very helpful in this regard, but we need to support the necessary changes in construction practices through training and market education about the benefits of investing in a low-carbon future.

What's Next?

Going Global and More Comprehensive

Our intent with the *Green Building Impact Report* is to establish an early benchmark for comprehensive evaluation of the environmental impacts of green buildings. It is a work in progress and our assessment in some cases revealed how little the world knows about the environmental aspects of green building performance.

We expect that future annual editions of the *Green Building Impact Report* will build on this initial effort, growing increasingly more comprehensive. Toward this end, the 2009 report will evaluate the impact of LEED buildings globally and will assess the trends in the world's hottest green building markets.

On the U.S. scene, we will address LEED Homes and some special markets such as school and retail applications of LEED, as well as a preliminary look at LEED for Neighborhood Developments (LEED ND). We also plan to have addressed LEED Commercial Interiors (LEED CI) questions regarding double-counting and to have determined how to accurately separate these impacts from those of other LEED buildings.

We welcome your feedback and suggestions. Please send them to GBIR@greenerworldmedia.com.

Appendix: Methodology

The conclusions of this report have their foundation in a spreadsheet model that quantifies and projects the total floor space of certified and registered LEED NC, LEED CS, and LEED EBOM projects. Based on data available and the methodology described below, we calculated six floor area streams of figures — Certified LEED NC, "Built to LEED" NC, Certified LEED CS, "Built to LEED" CS, Certified LEED EBOM, and "Built to LEED" EBOM.

2000-2008: When available, we used actual historical figures from the US Green Building Council. However, in some cases only aggregate figures were known, requiring estimates for the amount of floor space each category comprised. Using actual average floor space per project figures in specific years and categories along with the reported number of projects per year in each category allowed us to calculate annually added square footage. Finally, we used cumulative figures on LEED construction to date to work backwards and test the accuracy of our calculations. Because LEED was launched in an almost exclusively American context in its early years, the total floor area between 2000 and 2005 was predominantly — roughly 94% on average — comprised of US-based projects.

Since 2005, in tandem with the market's recognition of LEED as an internationally regarded and applicable standard, the number of overseas projects, and total floor space, has risen considerably. We thus took into consideration an increasing amount of floor space that comes from foreign projects (more than 20% of all LEED floor area), and subtracted an amount from our floor space figures in that has increased year-by-year. The commercial model evaluates only the environmental impacts of green buildings in the U.S.

In some of our results, we applied "LEED penetration" estimates to determine accurately the impact of green buildings as a function of their share of non-green construction. To determine the market share held by LEED, we compared LEED floor space against national figures. We used 2007 Department of Energy (DOE) *Buildings Energy Databook* published data on building stock in 2000 and 2005, as well as projections for 2015 and 2020. From these figures, we ascertained new construction annually as a function of the implied average annual rate of growth minus a calculated floor area that had reached the end of its useful life.

Comparing the cumulative annual addition of LEED construction against cumulative new construction since 2000 thus generated a "market penetration" figure of LEED for the six streams of data. Once these numbers were obtained, it was possible to get an idea to what degree LEED has infiltrated mainstream building and whether or not it has become a robust catalyst for changing the baseline case.

2015 and 2020 Projections: Current market penetration data served as the starting point for making a best guess on the near-future trajectory of LEED. We modeled our projections on a Pearl-Reed growth curve, which is an S-curve function that trends toward an upward limit that is often used to simulate and predict technology penetration trends.

Taking LEED as a type of technology and innovation, which is admittedly unlikely to reach full market penetration and therefore has a natural upper limit, we felt this would generate appropriately fitting figures. Because the different streams of LEED construction have so far penetrated the market at vastly different rates, we needed to adjust the Pearl-Reed curve variables accordingly. For LEED NC, which has already exhibited widespread market adoption, the curve was fitted along a shorter time frame — 10 to 15 years — to show that much of the expected market uptake has already occurred. For LEED CS and LEED EBOM, the curve was fitted along a longer time frame — 15 to 20 years — to reflect the likelihood that LEED CS and LEED EBOM have different market characteristics that will generate different uptake profiles. The figures generated through this modeling exercise were generally consistent with expectations.

For LEED EBOM, we had to create two "source streams," one from the pool of LEED NC certified buildings that go on to continue to certify under LEED EBOM and buildings from the existing stock that use LEED EBOM as their entry point. For the NC-EBOM migration, we assumed that 70% of NC projects migrate after a three-year time lag. The entry of the existing building stock was calculated using the S-curve methodology above that penetrated an "addressable annual market" of 10% of the current stock of buildings, based on an assumed 10-year renovation cycle.

Water Savings Methodology

We derived baseline water consumption figures from the US Geological Survey (USGS) figure for daily water use in order to obtain an annual per square foot figure for water consumption in commercial buildings.

Plumbing and Cooling Tower Savings: To derive water savings estimates in this area, we took a weighted average of the percentage of water saved in LEED buildings based on the percentage of projects that have achieved specific credit ratings and quantifiable (20% or 30%) water savings requirements. In order to ascertain total savings, we first multiplied the percentage savings times the baseline gallons of water consumed per square foot of commercial space. Taking climate disparities into consideration — e.g. warmer climates demand more air conditioning, and thus buildings in warm climates use more water in cooling tower applications — as well as the water consumption levels that differ according to the age of buildings, we conservatively took 13 gallons of water per square foot per day as the baseline number against which we compared NC and CS buildings, and 22 gallons against which we compared existing buildings. We finally used the derived gallons of water per square foot per day saved in green buildings and multiplied it by total LEED floor area to yield an aggregate figure.

Landscaping Water Reductions: To derive landscaping-related water savings, we similarly took a weighted average of the percentage of water saved in LEED buildings based on the percentage of projects that have achieved quantified landscaping water reductions. In order to ascertain total savings, we first multiplied the percentage savings times the baseline gallons of water consumed on landscaping per square foot of commercial space to get the per square foot savings. As with plumbing and cooling tower use, we took geographic water consumption disparities into consideration, and conservatively used 19 gallons of water per square foot per day as the baseline number of water used for landscaping. We finally took the derived gallons of water per square foot saved in landscaping of green buildings and multiplied it by total LEED floor area to yield an aggregate figure.

Wastewater Reductions: Wastewater figures were derived in a similar fashion, using an average of 40.9 gallons of water generated per square foot daily in commercial buildings. Considering that implied reduction in usage from efficient cooling towers is not included, the final estimated savings are believed to be a conservative estimate.

Energy Methodology

Given that this is our first attempt at a comprehensive impact assessment of LEED, we wanted to be conservative in our calculation methods. First, the impacts of LEED Commercial Interiors (LEED CI) are not included because we were concerned about issues of double counting that we were not able to resolve before the publication of the report. Given cumulative floor area currently in the CI system of over 50 million square feet and rapidly growing, this is not a trivial conservatism. In addition, several recent LEED standards, particularly LEED for Schools and LEED for Retail, were not included in our future projections, even though participation growth in those Application Guides has been phenomenal since their launches.

When ranges of impacts of LEED measures were calculated, we used the low figures derived. In addition, we based our savings on the actual thresholds in the LEED standard, rather than what was actually achieved. For example, if a project were able to generate 25% renewable electricity, that project only would be quantified at the 20% LEED threshold.

"Built to LEED": In evaluating the impacts of LEED we also created a category we call "built to LEED." Generally, these are projects that register, but don't certify — approximately 25% of registered projects, according to our research. While these buildings do not achieve the environmental impacts of LEED Certified buildings, their benefits are not zero and in aggregate they are not trivial. Though we do not have measured figures to corroborate the impact of LEED on these buildings, we assume that their achievement is half that of a certified project.

Weighted Averages: Additionally, we considered the hierarchy of benefits within LEED Certified projects: namely, that Platinum buildings generally outperform Gold, Gold generally outperform Silver, and so on. We obtained the credit tallies from over 750 LEED Certified projects from the Version 2.0 and 2.1 vintages and created profiles of "average" LEED buildings according to certification levels. We used this to derive a project-weighted average of resource savings for LEED projects. Next year we hope to use floorspace-weighted averages.

Energy Efficiency: LEED energy savings are measured in several different areas, including not just operational energy, but also reductions in commuting energy, water treatment energy, and lower materials embodied energy.

Because LEED CS addresses a smaller percentage of the building's energy systems, we assumed that a CS project would achieve 40% the energy savings of an NC project.

The DOE *Buildings Energy Databook* (2007) figure for primary energy consumption per square foot (241 kBtu/square foot) served as the average commercial energy use base case. This number was multiplied by the project-weighted savings, resulting in an average per square foot kBtu savings of 60.1 on the low end and 75.1 on the high end. The low-end scenario reflects an 80% measurement adjustment applied for the purpose of making a conservative estimate consistent with reported findings so far.

Renewable Energy Savings: We used the breakdown of LEED projects that have attained various percentages of on-site renewable energy generation to obtain a weighted average of total renewable source electricity green buildings have contributed. We introduced a 40% energy use adjustment for LEED CS floor area, and assumed that all renewable energy associated with LEED EBOM came in the form of renewable energy credits, or RECs.

M&V Savings: We took the Lawrence Berkeley National Lab study on the 2004 edition of "Cost Effectiveness of Commercial-Building Commissioning" (CBECS) as our starting point, multiplying the average costs saved as a percentage times the CBECS average energy cost per square foot to get average energy savings per square foot. We used a weighted average of the benefits of basic vs. advanced commissioning, and measurement & verification (M&V) to produce a per square foot dollar savings from commissioning and M&V.

About the Authors

Rob Watson is the Executive Editor of GreenerBuildings.com, the one-stop website for the green design, construction and operation of commercial and institutional buildings. GreenerBuildings.com is produced by Greener World Media, the leading media company focused exclusively on the greening of mainstream business.

Watson also serves as the chairman, CEO & Chief Scientist of the EcoTech International Group, which helps clients around the world achieve cost-effective high performance green buildings through design, technology and operations.

Under Rob's direction as the "Founding Father of LEED" and as its national Steering Committee Chairman between 1994 and 2005, the U.S. Green Building Council's LEED rating system became the most widespread and fastest-growing standard by which green buildings are measured worldwide. A pioneer of the modern green building movement for over 20 years, in 2007 Rob founded the EcoTech International Group to meet the fast-growing demand for green building technologies and services in China, India and the U.S.

Elizabeth Balkan has a background in environmental policy and sustainable development issues. For four years she worked in China conducting social and environmental compliance audits in the manufacturing industry, and monitored Chinese and International regulations. Elizabeth has carried out studies on China's energy intensive industries, energy consumption in Chinese buildings, and energy policymaking in Shanghai. She has been working with EcoTech International and its subsidiary, American SinoTech, to develop market transformation strategies. Elizabeth received a B.S., Foreign Service from Georgetown University and a Master's in International Affairs, Economics and Energy Policy from Columbia University.

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