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A reliable and trusted source for more than a century, MHC has remained North America's leading provider of construction project and product information, plans and specifications, industry news, market research, and industry trends and forecasts. In recent years, MHC has emerged as an industry leader in the critical areas of sustainability and interoperability as well.

In print, online and through events, MHC offers a variety of tools, applications and resources that embed in the workflow of our customers, providing them with the information and intelligence they need to be more productive, successful and competitive.

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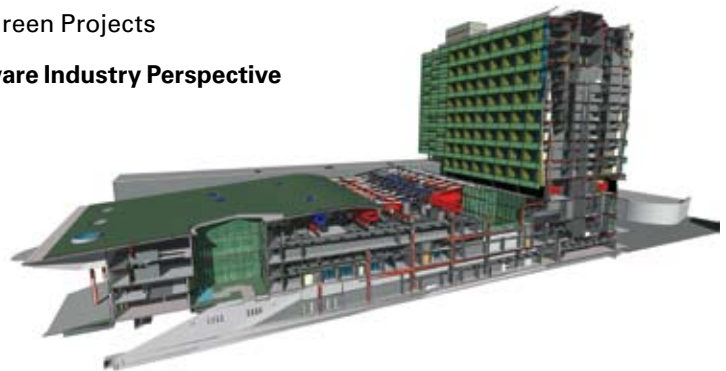
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 Southeast Quadrant, Silver Spring, MD;
 Shanghai Tower, part of the new
 super-tall district in Shanghai, China.
 Opposite page: Palomar Medical
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Introduction

GREEN BIM

Green building is rapidly transforming the design and construction industry in the United States. Simultaneously, a growing number of industry practitioners are embracing the advantages of building information modeling (BIM). As a logical development of these trends, green building project teams are increasingly discovering how BIM tools can help them achieve more sustainable outcomes. These tools provide immediate insight into how design decisions impact building performance. BIM also encourages an integrated design process—a critical strategy for making projects greener. Because of the way BIM facilitates green design, construction and sustainable outcomes, the growth of green building as an accepted, widespread practice is helping to accelerate BIM adoption.

This SmartMarket Report studies the symbiotic convergence of these formerly separate trends into an emerging practice referred to as Green BIM. We believe that all industry players—including design firms, contractors, owners and building product manufacturers—need to think strategically about the role Green BIM can play to help position them as leaders in the green building marketplace. To provide context for this evaluation, the report examines how BIM is used now on green projects and what BIM users see as the potential for Green BIM in the future. We found, for example, that Green BIM is poised for great growth. **78% of BIM users who do not currently use it for green projects expect to be doing so within 3 years.**

This projected growth in application of BIM tools for green projects is mirrored by the finding that current Green BIM practitioners are just starting to take full advantage of the potential of BIM for green building. **Only 17% of firms practicing Green BIM reported that they currently take advantage of more than half of the potential BIM offers for green projects.**

Highlighting the exciting evolution of Green BIM, the report also captures perspectives on its future from a broad range of green building experts and BIM technology leaders—as well as case studies that demonstrate a variety of Green BIM contributions to achieving sustainable outcomes. These real-life examples reveal specific advantages BIM brings to green building projects—enabling cutting-edge design and technology integration (see Shanghai Tower case study on page 44), prefabrication (see page 42) and better building performance and daylighting (see pages 24 and 26).

We want to acknowledge the U.S. Green Building Council, Mechanical Contractors Association of America and Autodesk, along with thirteen other corporate and association partners, for supporting the research for this study and helping bring it to the market. McGraw-Hill Construction looks forward to continuing to provide actionable intelligence to the industry on the emerging trends that will shape our collective future.

For more information on the methodology behind the data in this report, please see page 52.



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Executive Summary

GREEN BIM

Green BIM Is on the Rise

The strong growth of the green building market can encourage BIM adoption in the design and construction industry.

BIM tools enable highly sustainable outcomes through energy simulation and prefabrication. As a result, Green BIM practitioners use the tools more often and more fully than non-Green BIM companies. Additionally, all BIM users anticipate higher levels of BIM use to achieve a variety of sustainability goals.

Green BIM Is an Emerging Trend

Industry players agree that they are just beginning to tap the full potential of BIM to achieve their green objectives. Only 17% of Green BIM practitioners realize more than 50% of BIM's potential to help achieve green objectives. The fact that most green BIM practitioners believe they can achieve far more with BIM than they currently do demonstrates that the industry sees the strong potential for BIM to improve sustainable outcomes. It also supports the likelihood that the growth of green projects will drive the growth of BIM use in the industry and, ultimately, productivity improvements in the design and construction industry.

GREEN RETROFIT PROJECTS

Green BIM practitioners find BIM to be particularly useful for green retrofit projects. Over one quarter (27%) see BIM as highly applicable for use in green retrofits, and nearly half (49%) believe it is of medium applicability. Given the forecast that the market share of retrofit projects by value that are green will increase from 5%–9% in 2009 to 20%–30% in 2014 (*Green Building Retrofit & Renovation SmartMarket Report*, McGraw-Hill Construction, 2009), green retrofits promise to be a strong growth area for Green BIM.

MONITORING BUILDING PERFORMANCE

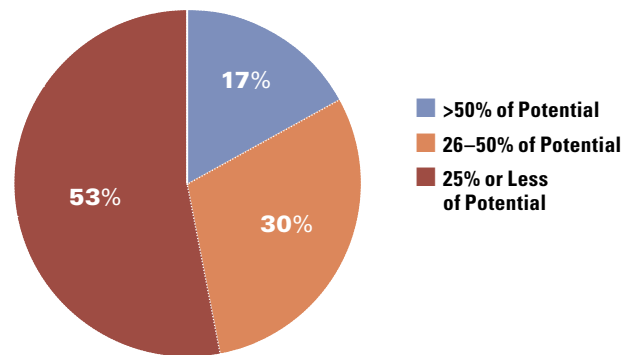
Long-term growth in use of BIM to help monitor building performance is expected—51% believe it has high potential for this purpose.

Strong Increase in Green BIM Practice Expected by All BIM Users

The industry perceives great value in using BIM on green projects, but so far market penetration has been limited. However, use of Green BIM is expected to grow dramatically. As can be seen at right, 78% of BIM users not currently utilizing Green BIM expect to be doing so within three years, including nearly 17% that believe it will happen in the next 12 months.

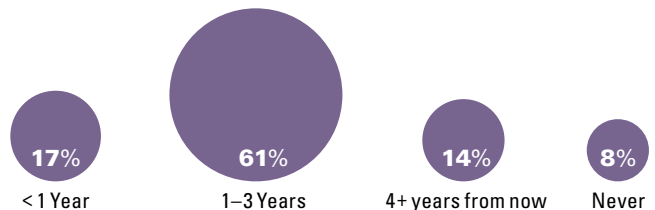
Realization of BIM's Potential to Achieve Green Objectives (according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010



Timing Expected to Green BIM Market Penetration (according to Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



CONTINUED

Steep Growth Expected in Use of Energy Performance Simulation

95% of firms using Green BIM will do energy performance simulations within two years, compared with 73% now. 79% of non-Green BIM firms will conduct such simulations, a dramatic increase from only 21% currently. This rapid increase reflects the growing importance of energy efficiency in buildings and the capacity BIM tools have for this purpose.

The main areas that non-Green BIM companies would like to simulate in the next two years are:

- Whole building energy use: 80%
- Lighting and daylighting: 69%
- Energy code compliance: 65%

Green BIM Practitioners Use BIM on More of their Projects than Non-Green BIM Companies

Nearly half (49%) of Green BIM practitioners use BIM on over 50% of their projects, compared to approximately one quarter (28%) of non-Green BIM companies. This result, combined with the more intensive use of BIM to both create and analyze models by Green BIM practitioners, suggests that, as the sustainability benefits of BIM become more well known, the growth of green building will help to increase the use of BIM by design and construction firms.

Players Driving Green BIM Adoption

Architects currently play a significant role in driving adoption of BIM for green projects, but creating more owner demand would be even more effective in penetrating the potential market. There are two key factors for driving owner demand—more education about how BIM saves time and money in the design and construction process, and an increased ability to use BIM effectively during the operations and maintenance (O&M) phase of a green building, rather than just during design and construction. These are also especially important when working with owners on existing building projects.

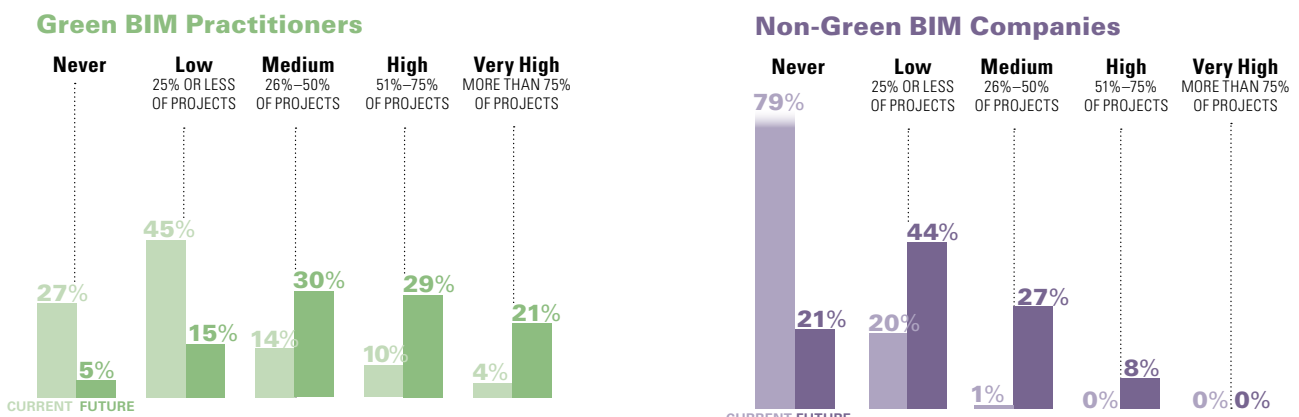
Triggers and Obstacles to Green BIM Adoption

The key factors that would influence a non-Green BIM company to start using BIM on green projects are owner demand (85%) and saving time and money (76%). 68% of A/E firms also note the availability of BIM tools as highly influential.

The main obstacles to BIM adoption are the blunt nature of the current tools and the perception that existing tools are easier to use. Therefore, as tools are adjusted to address the unique needs of green building, employment of this technology will increase even more rapidly.

Current/Future Use of BIM to Simulate Energy Performance

Source: McGraw-Hill Construction, 2010



Critical Green BIM Trends

Expert Views on the Future of Green BIM

While many Green BIM practitioners already find it an essential tool for green projects, BIM capabilities are still evolving—and at a rapid pace. The interviews and case studies conducted throughout this report reveal several areas that are key to the potential growth of Green BIM and its impact on the green building marketplace.

Software Integration

Nearly all the experts interviewed expressed the need for better software integration. The two types of software most frequently mentioned in this context are energy performance modeling software used by engineering firms and facility management software used during building operations and management. In both cases, the software currently cannot utilize the depth of data available in the BIM model. In fact, building models are frequently rebuilt by engineers in their own energy performance modeling programs rather than drawn from existing BIM models.

The USGBC plans to update its LEED Online software to allow BIM models to feed project data directly into the software. It has already put in place the necessary underlying architecture in the most current update.

Better software integration will allow project teams to utilize the BIM model more thoroughly and compare real building performance results with initial rough estimates.

Integrated Output from Different Building Systems

The ability to see an integrated view of all the building systems would improve sustainable outcomes by capturing the impact of design decisions across multiple parameters, allowing for more well-informed design decisions.

This kind of feedback also allows for improved communication with the client and other major players. Output that captures sustainability benefits from multiple systems in one, straightforward view would allow designers to communicate the benefits of green design more immediately to the owner and to all firms involved in design and construction—thus helping save key sustainable design elements from being value-engineered out of the project.

Greater Use of Integrated Design

Nearly all of the Green BIM experts interviewed asserted that BIM contributes to sustainable outcomes because it supports the use of integrated design. By

incorporating different areas of expertise from the early design stages, integrated design helps build better outcomes.

Modeling Standards

As the BIM industry continues to mature, a movement to develop modeling standards has the goal of helping achieve better integration across different types of modeling.

Increasing Use of BIM for Small Green Retrofit Projects

Most of the BIM users surveyed (88%) who are not currently practicing Green BIM expect that their firm will use BIM on a green retrofit project within two years. Greater recognition of how BIM can help achieve sustainable outcomes on green projects, including small retrofit projects, could help transform the industry's assumption that the value of BIM lies largely in coordinating large, complex projects. This could lead to more widespread BIM adoption across a firm's practice because most firms do many small projects.

Recognition of the appropriateness of BIM for small retrofit projects is also critical given the dynamic growth anticipated in the green retrofit market, which by 2014 is expected to grow to five times its size in 2009.

Using BIM for Building Performance Monitoring and Verification

The research demonstrates a high level of interest in monitoring and performance verification by all practitioners, evidence of the potential perceived in the value of BIM tools during the operations and maintenance phase of a project. Most would like to be able to capitalize on the data in the BIM model in order to monitor building performance and verify how well the building actually performs compared to the predictions during design. This will not only help improve energy efficiency, but it could also help designers improve their use of models to achieve more reliable outcomes in the future. ■

Data: Introduction

The construction industry in the last decade has seen the rise of two major trends that are fundamentally changing the approach to design and construction in the United States—green building and the use of BIM tools.

The green building movement has grown from a small group of enthusiastic practitioners to become a force within the industry. Concerns about climate change and energy dependence, as well as an economically driven focus on increasing efficiency and building performance in a cost-effective manner, have led many practitioners to adopt green building strategies. This change has been encouraged by legislation both incentivizing and mandating green building on the local, state and federal levels.

BIM adoption, while still relatively modest, is also having a fundamental impact on design and construction practices. To fully realize the value of BIM, many firms are transforming their approach to the process, with BIM enabling input from all players early in the design process, as well as allowing for greater use of prefabrication. The value proposition experienced by users, as reported in *The Business Value of BIM* (McGraw-Hill Construction, 2009), has led to significant growth in adoption in the last couple of years.

Although these trends have progressed independently, many practitioners at the leading edge of both find that green and BIM have remarkable synergies. Green design is best served by an integrated design process, with a holistic approach to all design and construction disciplines, and BIM adoption is in part based on its ability to facilitate integrated design. Also, green design and construction rely on improving building performance. Many of the tools of BIM, including energy use modeling and daylighting studies, provide better information on how design changes impact building performance than any traditional design tool. BIM models can also provide more information to product manufacturers, allowing for greater use of prefabrication, which can eliminate waste and makes the construction process greener and faster.

This report explores how firms that use BIM on green projects have found that it has improved project outcomes. It examines what drives them to practice Green BIM and how many of them are employing specific tools, and measures their satisfaction with those tools. It also compares those Green BIM firms to BIM users not currently using BIM for green projects, and examines how many of these non-Green BIM companies expect to employ Green BIM in the future and which tools they expect to be most useful to them in meeting sustainability goals. The report offers a glimpse into how the growing green market can be a major force in driving the overall adoption of BIM as the usefulness of BIM for green work becomes more widely known in the industry.

Note About the Data

The data in this survey is based on interviews with a range of industry professionals who use BIM tools, including architects, engineers, contractors, owners, building product manufacturers (BPMs), government agencies and consultants. Any data not broken out by firm type includes all these respondents. However, since architects, engineers and contractors comprise 84% of the total respondents, all firm type breakouts include only these firms.

For full methodology, see page 52.

For a glossary of terms used in the report, see page 50.

Data: Green BIM Adoption:

Triggers, Drivers and Obstacles for Current and Future Use of BIM on Green Projects

GREEN BIM DATA

Using BIM to Achieve Green Objectives

Industry players agree that they are just beginning to tap the full potential of BIM to achieve their green objectives. **Only 17% of firms using BIM for green projects feel that they currently take advantage of more than half of the potential BIM offers to achieve their green building goals.** This finding corresponds to the industry's general response to BIM use and its potential. It also suggests that the rise in green projects (see Green Building Market Sidebar on page 10) may encourage greater BIM adoption as the industry better understands the potential of BIM for achieving sustainable objectives.

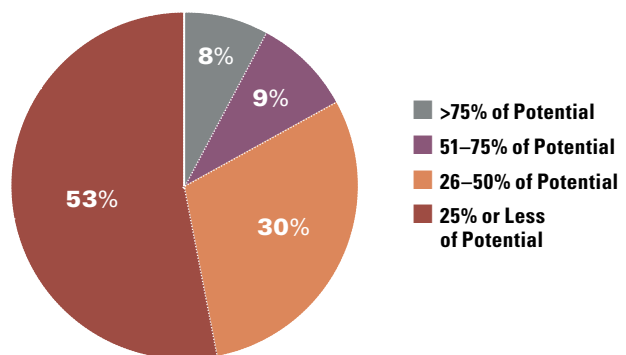
Predominantly Green Firms

Firms whose practice is primarily green (more than 75% of their total projects) report getting more of the full potential of using BIM to achieve their green goals. Nearly one quarter (24%) of these largely green firms state that they achieve more than 75% of BIM's potential for their green objectives—a rate three times higher than that of general respondents (8%, as can be seen at right).

This finding suggests that there is significant overlap between firms that are early and intense adopters of green and firms that are advanced BIM users. It also supports the idea that growth in green will lead to greater BIM adoption.

Realization of BIM's Potential to Achieve Green Objectives (according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010



Future Green BIM Adoption

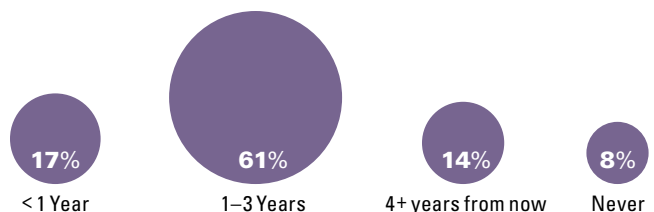
by Non-Green BIM Practitioners

Use of BIM for green projects is expected to grow dramatically in the relative short term—**78% of BIM users not currently using BIM on green projects expect to be doing so within three years.**

This extraordinary growth demonstrates the pent-up demand in the industry, which generally recognizes BIM's potential to improve green design and construction. It also reflects the growth in green building among contractors in particular, since contractors are the majority of potential new Green BIM practitioners.

Timing Expected to Green BIM Market Penetration (according to Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



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Triggers for Future Use of BIM for Green Projects

Clients are a critical driver to use of BIM on green projects—36% of respondents expect client demand to be the reason they will use Green BIM in the future.

28% indicate that market differentiation will encourage them to grow in future Green BIM use.

With 55% of the non-Green BIM companies being contractors—more than double the percentage of A/E firms—it is not surprising to see client demand and market differentiation as the most important triggers for increased Green BIM use. These factors correspond to the most important driver for non-practicing firms to start using Green BIM—differentiation for owner/client (see page 15).

DRIVING OWNER ENGAGEMENT

This result reflects the importance of increasing owner education about the benefits offered by BIM in general and for sustainable projects in particular.

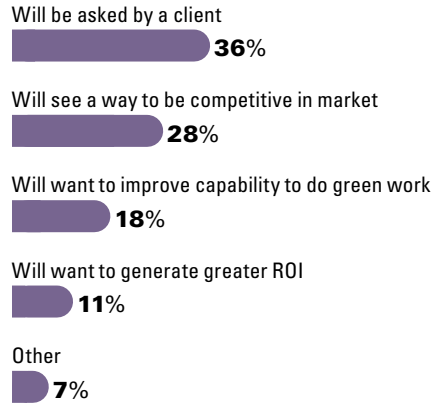
Although owner engagement in BIM overall is limited today (see page 35 and *The Business Value of BIM Smart-Market Report*, McGraw-Hill Construction, 2009), the development of tools that allow building owners to demonstrate their building’s performance could increase owner interest.

The building performance reporting requirements of LEED 2009, and of legislation in New York City and Washington D.C., will continue to drive the interest of owners in tools and methods that help them benchmark, measure and improve building performance. This, combined with the possibility of mandated carbon emissions reporting in future energy legislation, suggests that the market itself may be an important driver to owner interest in Green BIM as well as BIM overall.

One key element to encourage owner use of BIM is better integration of BIM with current facility management software. This will allow owners to have full access to the depth of information in BIM without requiring them to master design and construction software. (See page 36 for more information.)

Anticipated Triggers to Use of BIM for Green Projects (according to Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



Green Building Market Insight

The green building market expands as the economy contracts, with renovation work on the rise. This shift in construction practice creates opportunities across the industry.

In 2005, green building had just started to emerge in the market—comprising 2% of new construction. By 2008, that share had grown dramatically to 12% of commercial construction and 8% of residential construction.¹ McGraw-Hill Construction analysts estimate even greater market share in 2010 despite the economic recession, drastically lower levels of overall construction activity and higher perceived costs of green buildings, which prevails despite evidence to the contrary.

The renovation market has also started to present tremendous opportunity across the industry for energy efficiency and green building. Renovation activity comprised 61% of all construction projects in 2009.² McGraw-Hill Construction reported the green building share of that activity to be 5%–9%.³

Owners Driving Green Building

There are several players influencing the shift to green building, but most important of all is the owner. On the private side, large corporations are increasingly making commitments to greening the buildings in their portfolios. According to McGraw-Hill Construction, in 2009 more than one fifth of the corporate leaders of the largest companies in America were dedicated to having over 60% of their portfolio be green. More (42%) expect to do so by 2012.⁴ The influence of these owners on the market will help drive further growth.

The largest public owner is even

more dedicated to green building—the General Services Administration (GSA) has been a strong green building proponent and recently made a commitment that all its new buildings would have a net-zero carbon footprint by 2030. State and city government owners are also influencing their local construction markets.

As owners push for green buildings, other players will need to become experienced in delivering these projects—and delivering them on time and on budget.

Percentage of Green Work

Survey respondents reported nearly equal levels of green building work. However, 15% of all respondents report very high levels of green work. This notable percentage of firms dedicated to green building reveals

significant penetration in the market.

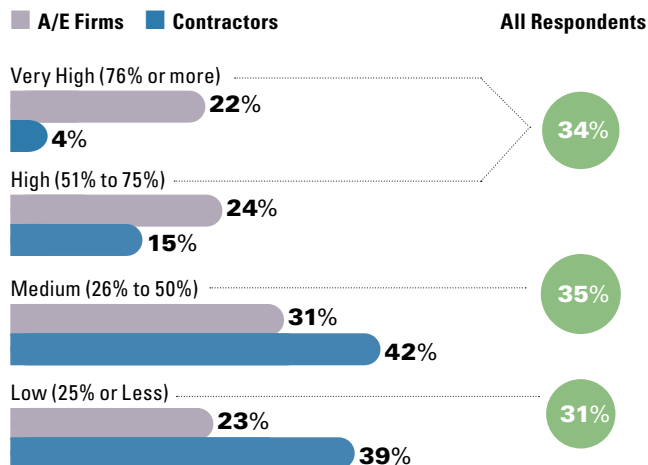
As with use of BIM, design firms are leading in the share of activity that is green—46% of the A/E firms have a high involvement in green projects, compared to 19% of contractors. However, contractor involvement in green building has been growing over time according to surveys conducted by McGraw-Hill Construction in 2005 and 2008.

Implications for BIM

The more owners understand the advantages of BIM for meeting their green—and cost savings—goals, the more BIM will increase. Key factors that will enable Green BIM growth include tools that can handle the complexities involved in addressing green building goals, apply to existing building projects and are easier to use. ■

Percentage of Green Work (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010.



¹ Green Outlook 2009, McGraw-Hill Construction, November 2008; ² McGraw-Hill Construction, Construction Starts Database, January–December, 2009; ³ Green Building Retrofit & Renovation SmartMarket Report, McGraw-Hill Construction, November 2009; ⁴ The Greening of Corporate America 2009, McGraw-Hill Construction/Siemens, September 2009.

Use of BIM on Green Projects by Project Type

Nearly all firms involved in Green BIM use BIM for new green construction projects. The fact that firms use BIM for nearly twice the percentage of major green renovations as they do for minor green retrofits suggests that BIM is generally perceived as more applicable to larger, more complicated projects.

The McGraw-Hill Construction building stock database reveals that over the last 20 years, larger volume projects—those over 50,000 square feet—have grown in terms of total area constructed relative to smaller projects. However, the data also demonstrate that large volume projects are more susceptible to the state of the general economy. Thus, the current economic downturn has impacted this market more than the market for smaller projects.

The current economy has also increased attention to the green renovation and retrofit market in existing buildings. These are typically smaller projects.

Therefore, in current economic conditions and in the immediate future, BIM growth would be encouraged if BIM were more widely perceived as applicable to minor retrofits. (For more study results related to BIM on retrofit/renovation projects, see page 38.)

Variation by Firm Type

A/E firms use BIM for a larger percentage of their green renovation projects than contractors do, especially for minor renovations. This result affirms the previous finding that a higher percentage of design firms have incorporated BIM into their basic practice compared to contractors.

■ Major Retrofits/Renovations:

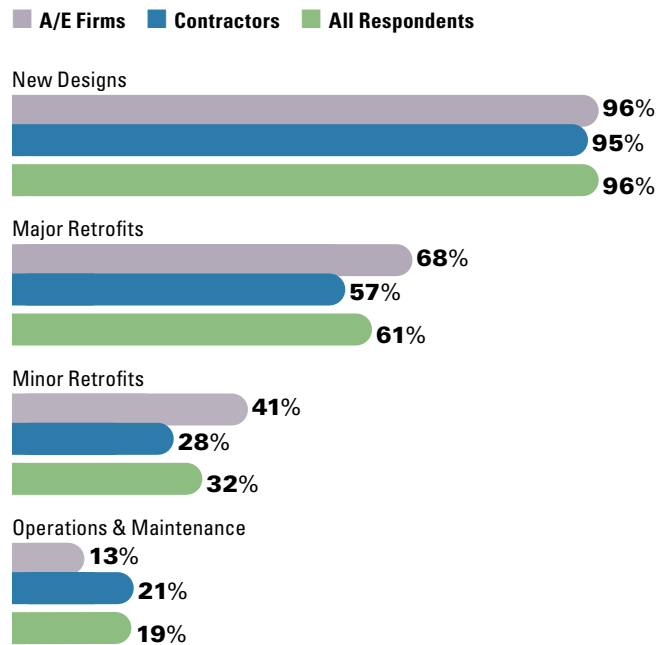
- A/E Firms: 68%
- Contractors: 57%

■ Minor Retrofits/Renovations:

- A/E Firms: 41%
- Contractors: 28%

Green BIM Project Types for Green BIM Practitioners (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Operations and Management

Given that the majority of respondents are design firms and contractors, it is not surprising that the percentage of projects for which BIM was used for operations and maintenance (O&M) is only 19% since these firms typically are not charged with O&M responsibilities.

Demonstrating the usefulness of BIM for O&M would provide additional evidence to building owners about the value of BIM for them (see page 9).

■ 21% of contractors use BIM for O&M, compared with 13% of A/E firms.

■ 27% of the firms whose practice is largely in green projects (over 75%) use BIM for O&M.

■ When firms use BIM for O&M of green buildings, they tend to do so more often for minor projects, as opposed to the way BIM is used in the design and construction phases:

- Minor Retrofits/Renovations: 35%
- Major Retrofits/Renovations: 25%
- New Projects: 19%

Achieving Green Innovation Through Integrated Design

Palomar Medical Center West
 ESCONDIDO, CALIFORNIA

GREEN BIM

The designers of Palomar Medical Center West believe that the concept of a green hospital should extend beyond energy and water savings. For them, a sustainable approach involves incorporating nature as much as possible in the building. Tony Moretti, AIA, CSI principal at CO Architects, explains, “The building was all about how to integrate nature into a facility that is otherwise extremely technology driven.” Critical to that vision were the terrace gardens on every floor, multiple courtyards and an expansive, undulating green roof that, when viewed from the patient tower, connects the building to the hills beyond.

To achieve that vision, the entire design and construction team—from the client to the engineers to the contractors—had to share the same goals. The team at CO Architects found that BIM was invaluable in creating the integrated team necessary

to build a facility true to their original green philosophy.

Early BIM Adopters

When design on the Palomar Medical Center West began in 2004, use of BIM was rare. However, the principals at CO Architects felt that BIM was the direction they wanted to take in the firm. According to Moretti, “We believed in the promise of BIM. We knew this project was going to be going on for a long time, and it became almost impossible for us to envision working into the future on this project in the old-fashioned way.” Tom Chessum, FAIA also a principal at the firm, agrees that they took a calculated risk by tackling the project in BIM: “It was a leap of faith, but well-founded faith.”

Integrated Design

An important part of the BIM value proposition for them was its ability to facilitate an integrated design

approach. “When we talk about BIM,” states Moretti, “we are also talking about integrated design. BIM is a technology that has made this integrated project delivery method feasible, just brought it to life. You really can’t have one without the other.”

They found that BIM provided several advantages in putting together their team. First, it attracted more sophisticated firms. All of the major trades and players were involved in BIM, including structural, MEP, exterior wall, fire protection and the construction manager.

Another critical advantage was the way in which BIM helped them make the process of construction more sustainable. And for the design team at CO Architects, the green design process and the green final building are strongly interconnected. “You could design a sustainable building without BIM. But what you can’t do is design and construct it in a truly



© CO Architects

One-way truss system (left) and rolling green roof construction (right) at Palomar Medical Center West

CONTINUED

Palomar Medical Center West ESCONDIDO, CALIFORNIA

sustainable way that goes above and beyond the traditional approach, such as use of the LEED checklist or the Green Guide for Health Care," states Frances Moore, AIA, LEED AP, CO Architects associate principal.

BIM and the integrated design process allowed the architects to share their larger green vision for the building, not just the individual components, with the entire integrated team. Chessum affirms, "The transparency that the use of BIM brings added to the success of the green ideas. [The green approach] survived the usual challenges of budgets and risks, and all because everybody believed in them. Everyone understood them, and they all bought in. And it is being built that way because of that buy-in."

Role of the BIM Architect

One surprising element for them was the way in which, counterintuitively, an integrated design approach using BIM actually reinforced the importance of the architect. "It puts us as architects in the position to guide [the team] by explaining to them what the overriding design goals and concepts were and to lead all that to fruition with their buy-in," explains Chessum, "as opposed to the old method of meeting the contractors after they... have made their own interpretation of our documents that weren't quite right, forcing us to have to defend the design."

Key Sustainability Feature: Green Roof

An integrated team approach with all parties working toward the same goal was most critical in the design of the rolling green roof in the Diagnostic and Treatment wing. By extending

a view of nature into the patient tower overlooking it, the green roof was essential to the fundamental green goals of the building.

The roof was also one of the most challenging design elements of the building because it involved unusually long spans underneath. The goal was to create a column-free surgical area to allow for maximum adaptation of the space. Given the rapid evolution in medical equipment technology, this flexibility was important to keep the building up-to-date in the future. It is also fundamentally green since an open, easily re-programmable space minimizes the need for future demolition and rebuilding.

However, such a long-span space under a green roof, and one with a rolling design, was a "highly integrated design [that] required the involvement and input of the whole team to make it work the way it was supposed to," according to Moretti. Originally planned as a two-way truss system, an analysis of the design in BIM by the steel subcontractor led to the selection of a one-way system instead, an approach that saved material, money and time without compromising structural integrity.

The designers believe the roof demonstrates the power of an integrated team's shared vision. "Things like [the roof] are always value-engineering targets, but it got a certain momentum because so many people got behind it," says Jennifer Knudsen, AIA, senior associate.

Prefabrication

BIM and integrated design also allowed the project to take advantage of prefabrication. Moore reports

that this is the first major health care project to prefabricated 100% of the piping. The design team credits the prefabrication process with helping to achieve efficiencies in labor and materials and to reduce construction waste.

Designing in BIM

CO Architects now only designs in BIM. According to Chessum, "We model first and look for opportunities to share and collaborate later." ■

Project Facts and Figures

stats

Owner

Palomar Pomerado Health

Architect

CO Architects

Associate Architect

Anshen+ Allen

Structural Engineer

KPFF Consulting Engineers

MEP Engineer

M-E Engineers, Inc.

Landscape Architect

Spurlock Poirier

Lighting Design

Horton Lees Brogden
Lighting Design

Construction Manager

DPR Construction

Size

736,000 square feet

Construction Cost

\$612,000,000

Started

October 2007

Scheduled Completion

April 2012

Green Certification

Green Guide for Health Care Rating System (Pilot Project)

Green Design and Construction Activities Undertaken with BIM

Design and analysis of complicated systems that impact energy use are the most common green activities undertaken in BIM by Green BIM practitioners.

The top three activities—energy performance, lighting analysis and HVAC design—all have a major impact on building performance in terms of carbon emissions, energy use and cost savings. HVAC design also impacts indoor air quality, another key green building consideration. In addition, robust tools currently exist in BIM to perform these analyses.

Electrical design lags behind HVAC design in BIM adoption—only 38% of all respondents indicating that they use BIM for their electrical work.

Variation by Firm Type

A/E FIRMS

The green activities undertaken by the largest percentage of A/E firms in BIM are ones that help assess and improve overall building performance in the early design phases:

- Energy Performance (67%)
- Lighting Analysis (60%)
- HVAC Design (52%)

CONTRACTORS

Cost estimation is the tool most commonly used by the largest percentage of contractors (55%). Nearly as many use it for HVAC design (53%), which is the only other category reported by more than half of the contractors surveyed.

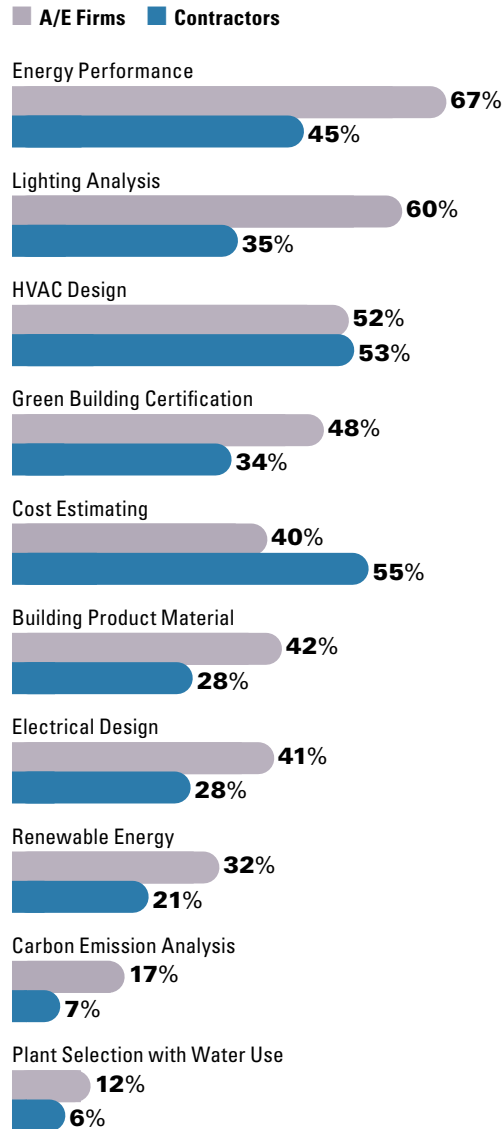
Renewable Energy Design

29% of all respondents report using BIM for renewable energy design.

According to the findings in the *Commercial and Institutional Green Building SmartMarket Report* (McGraw-Hill Construction, 2008), only 35% of all industry players are specifying or using on-site renewable energy. These similar results indicate that most Green BIM practitioners are sophisticated BIM users (see page 20) and that most Green BIM A/E firm practitioners are more heavily involved in green (see page 22). This suggests that as users become more involved in green building and in Green BIM practice, the application of these tools for on-site renewable energy design will likewise increase.

Top Green Design/Construction Activities with BIM for Green BIM Practitioners (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Green BIM Implementation Drivers (according to Green BIM Practitioners)

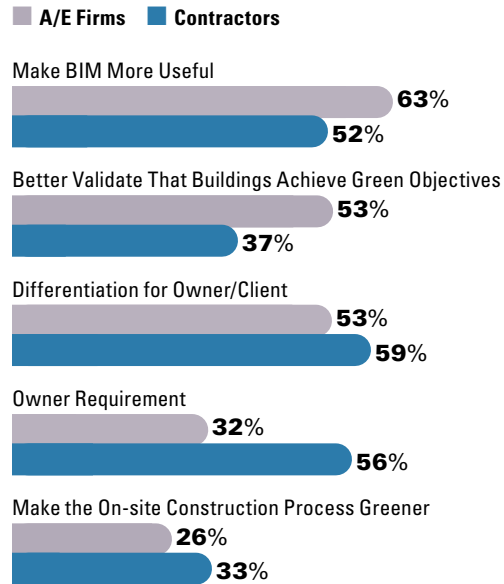
The influence of the owner is the primary driver for contractors to use BIM on green projects, whereas A/E firms place greater importance on how BIM helps them to achieve their sustainability goals. In fact, while owner requirements were a driver for 56% of contractors, that factor only influenced 32% of the design firms.

This finding corresponds to the role that A/E firms, architects in particular, have played as vanguard BIM adopters who have influenced other players, including owners, to consider BIM.

It is also consistent with the influence owners have on contractor decisions when it comes to green building activity overall. As reported on page 9, future triggers for BIM adoption by non-Green BIM practitioners, the majority of whom are contractors, are primarily client demand and market competitiveness. This further demonstrates the potential role of building owners in encouraging the market for BIM.

Influence of Different Drivers to Green BIM according to Green BIM Practitioners (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Green BIM Adoption Drivers (according to Non-Green BIM Companies)

Design firms and contractors that are not Green BIM practitioners agree that the top two drivers for using BIM on green projects are owner demand (85%) and saving time and money (76%). Each of these factors has a direct impact on a firm's bottom line and competitiveness.

Another factor considered to be highly influential by the market overall is the demand created by design firms. As early adopters, A/E firms have been, and continue to be, an important driver to widespread BIM adoption—over 50% of respondents recognize the role of those players in promoting initial use of Green BIM.

Variation by Player

A/E FIRMS

Tool availability resonates strongly with design firms (68%) as a key driver for Green BIM adoption. As other results have demonstrated, A/E firms currently are driven far more by BIM functionality than other players.

CONTRACTORS

Contractors are highly motivated to make construction sites safer, with almost half (46%) regarding this point as influential.

Though contractors place less emphasis on making sites greener as compared to safety, when they start using BIM on green projects, more of them believe it is important as compared to A/E firms.

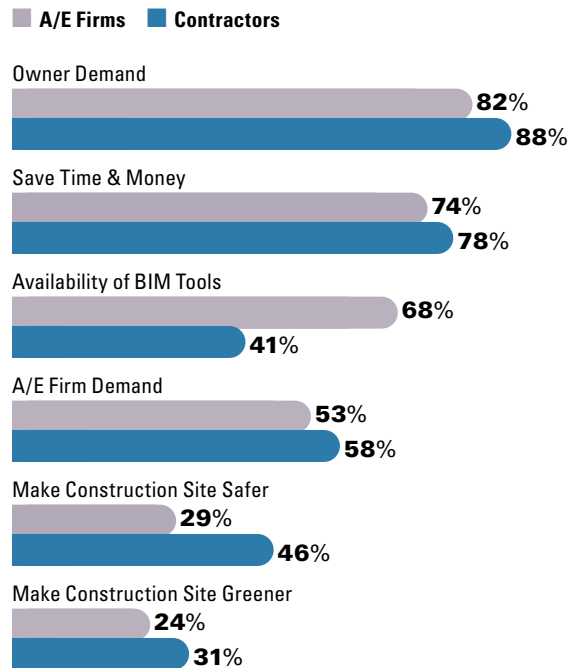
Factors Influencing Decision Not to Use BIM on Green Projects

More than half (53%) of all firms not currently practicing Green BIM report that they do not have a need to do it. That result could be influenced by a variety of factors, including lack of direct client demand and fewer green projects in their current pipeline. A higher percentage of contractors (61%) felt this was an influential factor than A/E firms (42%).

The remaining factors (see chart at right) were all considered influential by a higher percentage of A/E firms than contractors. Functionality is again key for most of these issues, corresponding to the general trend that design firms are impacted more by functionality and contractors more by owner demand and market factors.

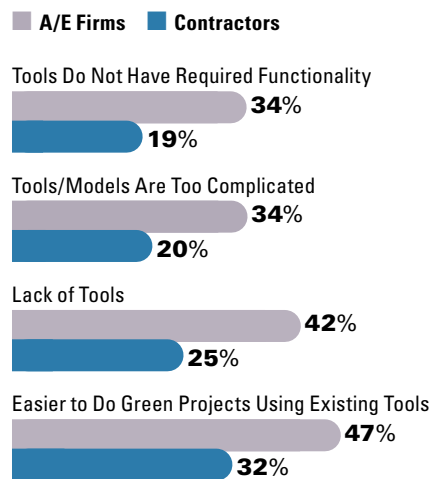
Influence of Factors behind Start in Green BIM Practice by Respondent Firm Type (according to Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010



Influence of Factors Behind Not Using BIM for Green Projects (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



BIM and Green Design: The Technology Software Industry Perspective

The next generation of BIM applications will include better interoperability and more effective analytical tools, including energy lifecycle analysis.

The use of BIM is increasing among architects, engineers, contractors and subcontractors. Furthermore, it can be a vital green design tool because it allows users to weigh various design options and their corresponding impact on green building performance.

Implementation of BIM could enable many energy-efficient and environmentally-conscious designs, such as passive design concepts, to be addressed at the very beginning of a project. When the building's size, shape and orientation are developed to perform in conjunction with the natural elements, requirements for heating, cooling, ventilation and electrical loads can be reduced substantially.

With this in mind, technology software firms are busy working on the next generation of BIM applications that focus on interoperability, integration and fostering a collaborative design process that improves constructability within budgets and schedules and engenders better green outcomes.

Future Goals

Huw Roberts, Bentley Systems' global marketing director, sees connectivity between systems as the next big step for BIM technology with respect to green design. He emphasizes that connectivity must be established, not just between BIM and analytical software, but also between different aspects of the BIM process. He believes interoperability of systems will yield the best results for green building design issues that

“[Good translation of large quantities of data from the model to analytical tools] is where the next generation of BIM tools can have an incredibly important future in making sure the construction industry is more productive and green.”

—Don McLean, president, Integrated Environmental Solutions

span multiple disciplines and multiple phases of work, because interoperability will allow all the participants to contribute directly to improve the design model. “In order to be able to connect the mechanical, electrical, architectural, structural and utility systems,” he says, “they will need to talk to each other in a dynamic and friendly way.”

As a result, developers of BIM applications have become one of the driving forces behind interoperability standards such as the Industry Foundation Classes (IFC), which allows the exchange of the 3D model's information for generating building simulations across multiple applications.

John Kennedy of Autodesk has observed that some of their users are somewhat overwhelmed once they get the results of their calculations. He sees simplifying the workflow as the next goal for their analytical tool, as well as offering guidance throughout the process.

Meanwhile Don McLean, president and founder of Integrated Environmental Solutions, points out that there is a strong need among design and construction professionals to effectively manage large quantities of data and translate the information from a BIM model to an analytical tool. Currently he believes the quality of translation of information for analysis is not satisfactory. He affirms, “This is where the next generation of BIM tools can have an incredibly important future in making sure the construction industry is more productive and green.”

According to Miklos Sved, product development manager at Graphisoft, the next step for BIM will be its use for determining the accurate lifecycle of a building's energy performance, a core component of green buildings. He states that there are isolated tools in the market that claim they can do this, but a tool that provides a seamless workflow from the building information model all the way to accurate lifecycle analysis has not been developed yet. According to him, the software developers at Graphisoft are hard at work attempting to build this tool. He believes that this is the next frontier for BIM.

At a time when creation of better buildings requires the economical and sustainable use of resources, design and construction firms must have the technology tools to find the best solutions. As the demand for green building increases, software developers will need to create the tools to meet this demand. ■

Envisioning Green in a Super-Tall Building

Shanghai Tower

SHANGHAI, CHINA

Shanghai Tower is the tallest of a trio of buildings designed to represent China's past, present and future in its first super-tall district. The tower's deeply sustainable design and striking glass spiral form make it the vision for the future. From the start, the owner, Shanghai Tower Construction & Development Co., Ltd, and the design architect, Gensler, realized that use of BIM and integrated design were

essential to deal with the complexity of the structure, coordinate an international team and achieve their green goals.

Dealing with Complexity

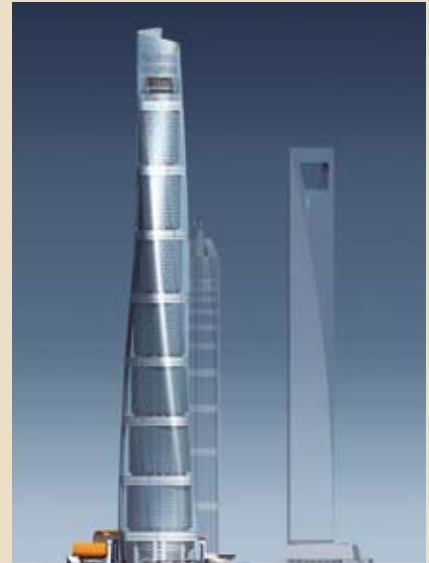
The tower is composed of nine cylindrical buildings stacked on top of each other, encircled by nine public atria. It also features a double glass facade, with a circular inner curtain wall structure enclosed by a triangular exterior curtain wall. The second facade rotates slightly as it rises, creating a spiral form that is central to the building's sustainability because it reduces the wind load and assists with rainwater harvesting.

Michael Concannon, production coordinator at Gensler, affirms that using BIM for Shanghai Tower "was beneficial for us to understand the entire scope of the project." He explains that design of the double facade in particular had to be done in three dimensions to understand the nuances. In fact, Christopher Chan, design director at Gensler, believes that Gensler was able to design a more complex facade because they used BIM.

Modeling the complicated dual facade in BIM allowed for a process between the consultants and designers that Chan explains "was not only less costly, but actually went a lot smoother and faster." During construction, BIM data will also support better coordination with the curtain wall manufacturers.

Team Coordination

BIM also allowed the entire project team to share a vision for achieving green goals. According to Grant Uhler, AIA, LEED AP, principal and senior project director for Shanghai



Shanghai Tower

© Shanghai Tower Construction & Development Co., Ltd

Tower, "Being able to create a BIM model and visualize for the client, for the engineering groups, for the contractor, what we are trying to do from an efficiency standpoint was really beneficial." All team members were able to fully visualize the project using BIM tools.

Chan notes that the tools help make team coordination a much leaner process. On previous projects with an international team, he remembers the "huge, full-size drawings being shipped back and forth, literally the same set that gets marked up, sent back, commented on and forwarded; it was just a nightmare." On this project, working digitally replaced that cumbersome process. According to Chan, "That doesn't just reduce the carbon footprint enormously, but it also saves a lot of time and money, and in this day and age, who doesn't want that?"

Both the design team and the owner also credit BIM with increasing the owner's input into

Project Facts and Figures

stats

Owner/Developer/ Construction Manager

Shanghai Tower Construction & Development Co., Ltd

Design Architect

Gensler

Local Design Institute

The Architectural Design and Research Institute of Tongji University

Structural Engineer

Thornton Tomasetti, Inc.

MEP Engineer

Cosentini Associates

Landscape Architect

SWA Group

Size

6.4 million square feet (tower and podium)

Height

128 stories (121 occupiable)

Started

November 2008

Scheduled Completion

2014

Green Certification

LEED NC Gold (Pre-Certified)

Green Building Three-Star Certificate from the China Green Building Council

CONTINUED

Shanghai Tower SHANGHAI, CHINA

the project. Gu Jianping, board director and general manager, and Ge Qing, design director, prioritize using BIM on their projects because it allows them to work with the design and construction team to “plan, coordinate and control all aspects of the work.” They anticipate BIM playing a role in the tower’s daily operation after construction is complete, coordinating a very different team than the one currently in place. “We will take advantage of the model to optimize the operation scheme, equipment management, real estate management and emergency management, to realize the greatest returns for the developer.”

Achieving Green Goals

The insight using the BIM tools provided was critical to their attempt to achieve high LEED and Three Star (the Chinese green building certification program) ratings. Not only did they create a sustainable, super-

tall building, but they were also able to achieve significant cost savings in many of the green elements.

TOWER DESIGN

As stated above, the complex shape and structure of the tower enabled by the BIM tools contributes to several aspects of greening the building, including harvesting rainwater and using wind turbines. The greatest impact, though, came from the reduction of materials used in building the tower.

Uhlir explains that BIM technology allowed them to design the most efficient structural frame of the tower. Tests gauging the impact of the taper and rotation of the tower led the design team to develop the current exterior configuration, which reduces the windload by about 24%. This reduction makes it possible to keep the building stiff using less steel, saving energy as well as material since steel is a particularly energy-intensive product. As Uhlir

points out, the cost savings are also significant: “Each 5% reduction equates to roughly about USD \$12 million in savings.” The tower design also uses 14% less glass than a square building with the same area.

Another way the complex dual skin of the building increases its sustainability is that it creates nine public atria between the inner and outer curtain walls that will function like plazas in a traditional cityscape. Concannon explains that, through these gathering spaces, “the building itself is a community.”

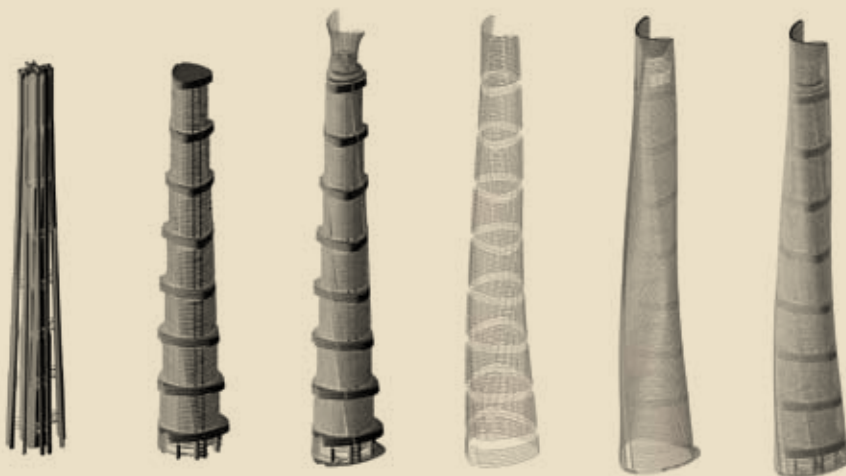
CUSTOMIZATION

According to Chan, bringing suppliers into the design process earlier also saved materials and created value for the owner by allowing them to minimize customization. High profile, complex projects normally involve a large number of customized products. By finding existing high-quality products that met their demands, they were able to add “another layer of savings to the whole process, and to the carbon footprint, due to the fact that [the building product manufacturers] don’t have to create a whole new assembly line just to create a grand new thing that is specific to this project.”

ENERGY SAVINGS

Concannon also credits the built-in tools in BIM with assisting them to achieve their significant energy use reduction goals. As Chan explains, modeling provided the design team with specific, quantitative feedback on building energy performance. He believes that using BIM helps alleviate concerns about not hitting the metrics for targeted LEED points. ■

© Shanghai Tower Construction & Development Co., Ltd



Innovative facade model images for Shanghai Tower

Data: Profile of Green BIM Practitioners

GREEN BIM DATA

Frequency of BIM Use for Green Projects

Green BIM practitioners use BIM on more projects overall than do firms not using BIM for green projects.

BIM use on over 50% of projects:

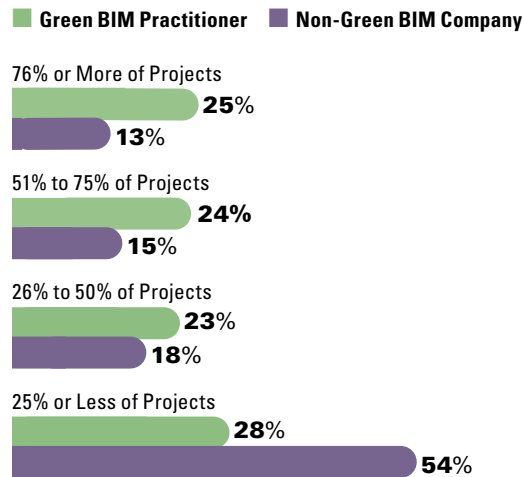
- Green BIM Practitioners: 49%
- Non-Green BIM Companies: 28%

Additionally, more than half of non-Green BIM companies are using BIM on less than 25% of their projects.

These results suggest there is greater BIM experience and sophistication among firms who practice Green BIM.

Frequency of BIM Use (Green BIM Practitioners vs. Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



Types of BIM Use

Firms that use BIM for green projects have a different use profile from firms that do not. Green BIM practitioners both analyze and create models with BIM two-thirds more often than those not using BIM for green projects—59% versus 35%. This result includes all analysis that can be done in BIM, including those that improve outcomes that are not necessarily green.

MODEL CREATION ONLY

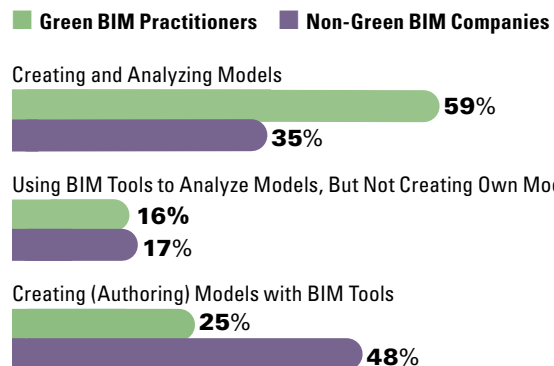
- Green BIM practitioners: 25%
- Non-Green BIM companies: 48%

CREATE AND ANALYZE MODELS

- Green BIM practitioners: 59%
- Non-Green BIM companies: 35%

Overall BIM Involvement (Green BIM Practitioners vs. Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



CONTINUED

Profile of Green BIM Practitioners

Types of BIM Use CONTINUED

GREEN BIM DATA

Green design and construction require greater analysis of building performance, so this result corresponds to advantages BIM tools offer for greening a project. As the green building market increases, the effectiveness of BIM analysis tools at improving green outcomes may lead to increases in BIM use overall as well as specifically for analysis.

Variation by Player

Among those who are not using BIM for green projects there is a noticeable difference between the percentage of A/E firms that both create and analyze models, and the percentage of contractors that do so. However, there is little difference among firms that are Green BIM practitioners.

NON-GREEN BIM COMPANIES: CREATE AND ANALYZE MODELS

- A/E firms: 24%
- Contractors: 46%

GREEN BIM PRACTITIONERS: CREATE AND ANALYZE MODELS

- A/E firms: 61%
- Contractors: 62%

This demonstrates a significant correlation between BIM for analysis and for green projects.

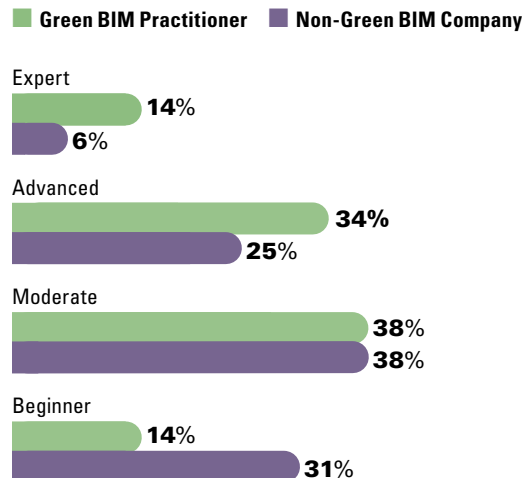
Company Expertise with BIM

Green BIM practitioners are more advanced in their use of BIM than firms that do not use BIM on green projects.

- **Green BIM Practitioners: 48% identify themselves as Expert or Advanced**
- **Non-Green BIM Companies: 31% identify themselves as Expert or Advanced**

Level of Expertise with BIM (Green BIM Practitioners vs. Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



Green BIM practitioners do a much larger share of green projects as part of their overall practice compared to non-Green BIM companies. Green insights and approaches tend to grow with increased involvement with green projects, and this result suggests that Green BIM practitioners may have greater depth of experience with green work than non-Green BIM companies.

Green Projects Comprise More Than 50% of Total Projects (high and very high levels seen at right):

- Green BIM Practitioners: 39%
- Non-Green BIM Companies: 16%

Years Practicing Green BIM

Green BIM is an emerging trend. Relatively new adopters (those with less than two years experience) and moderately experienced adopters (those with two to five years of experience) are at roughly equivalent levels—48% versus 42% respectively.

Not surprisingly, both categories significantly exceed the percentage of early, experienced adopters who account for 10% of the total Green BIM practitioners.

Variation by Firm Type

Design firms are further along the Green BIM adoption curve than contractors. This follows the general pattern for adopting green building strategies in the industry, where more A/E firms did so compared to other industry players at the start of the green building movement. However, contractors are shifting toward adoption rapidly.

■ **More than Five Years Green BIM Experience**

- A/E firms: 12%
- Contractors: 7%

■ **Less than Two Years Green BIM Experience**

- A/E firms: 44%
- Contractors: 52%

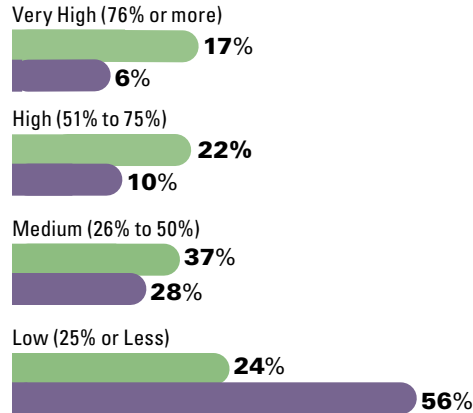
Company Level of Green Building Work

Percentage of Green Work

(Green BIM Practitioners vs. Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.

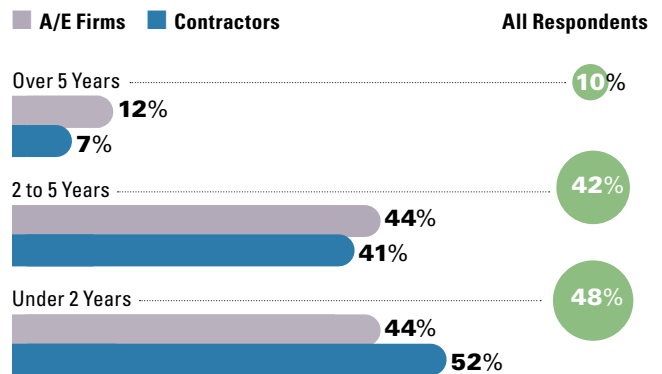
■ Green BIM Practitioner ■ Non-Green BIM Company



Length of Experience with Green BIM

(by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Profile of BIM Users

BIM itself is still an emerging trend in the construction industry. The data demonstrate that design firms lead in both frequency of BIM use and green projects, while overall BIM adoption continues to grow.

Frequency of BIM Use

44% of firms using BIM are using it on more than 50% of their projects.

This indicates some growth in the frequency of BIM use over previous studies. In *The Business Value of BIM* (McGraw-Hill Construction, 2009), 56% of BIM users were using it on 30% of their projects or less. This current survey reveals 56% are using it on 50% of their projects or less, with only 34% of the total respondents using it on less than one quarter of their projects. This shift in a one-year period demonstrates the growth potential of BIM.

Design firms report using BIM on a larger percentage of projects than contractors. **Over one third of A/E firms (36%) use BIM on over 75% of their projects, compared to only 11% of contractors.** The higher level of use by design firms is consistent with their position as early BIM adopters.

Types of BIM Use

The majority of BIM users are implementing it fully, with 54% creating models as well as analyzing them in BIM. An additional 29% use it only to create models, and 17% use it only to analyze models. This result is relatively consistent with previous surveys.

There is no significant variation by player among the firms who are fully implementing BIM by using it to create models and analyze them—53% of designers and 58% of contractors.

However, for firms who are not performing both functions with BIM tools, A/E firms more commonly author models, while contractors more commonly analyze models without creating them. These results are consistent with the respective roles of these players in the construction process.

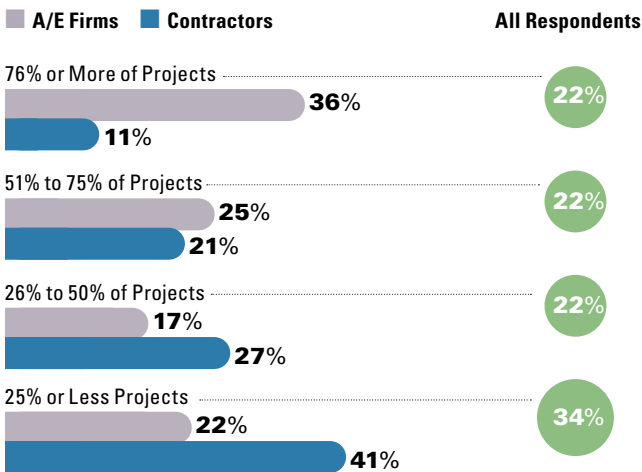
Share of Green Projects

BIM users has a slightly different level of green building activity as compared to their professions as a whole. In surveying a representative sample of construction industry players, McGraw-Hill Construction found that 13.5% of all architects have a very high percentage of green work, whereas 22% of BIM users report this same level of green work. Accordingly, those reporting at the lower levels also show the BIM user as more heavily involved in green—26% of architects in the entire industry are at the lowest levels of green activity as opposed to 23% of BIM users.

The opposite trend occurs for contractors that use BIM. Of the overall contractor community, 7.5% are engaged at very high levels of green building, compared to 4% of BIM users, and 36.5% are at the lowest levels as compared to 39%. ■

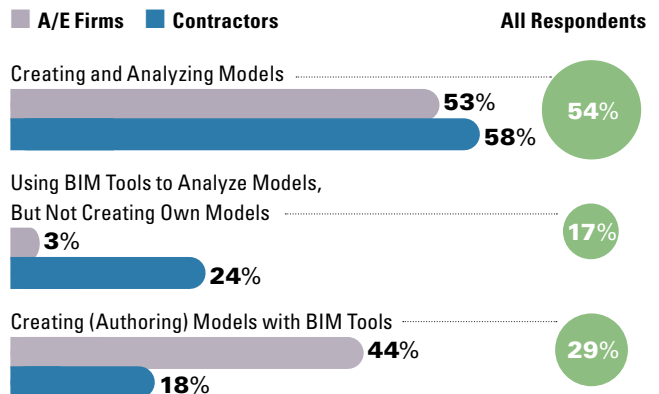
Frequency of BIM Use (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010.



Overall BIM Involvement (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010.



Data: Building Performance and Energy Modeling

GREEN BIM DATA

Frequency of Simulating Building and Energy Performance

65% of all Green BIM practitioners have performed total building performance simulations in their BIM models. Energy performance simulation is even more common—73% use these tools in BIM.

Despite this, most Green BIM practitioners are only deploying these tools on a small percentage of their projects. Out of the firms who do simulations in BIM for green projects, 62% do energy simulations on one quarter or less of their projects.

The same is generally true for total building performance—67% of firms who do total building performance simulations in BIM do so on one quarter or less of their projects. This result indicates that firms are selecting applicable projects on which to perform whole building and energy simulations rather than generally applying them to most projects.

One factor potentially impacting long-term use of these tools is public policy about energy efficiency. The U.S. Department of Energy is working to provide marketable solutions to commercial and residential buildings to achieve market-ready, net-zero energy commercial buildings. The net-zero strategy combines use of energy efficiency and onsite renewable energy, resulting in a building that generates as much energy as it uses. In addition, incentives to encourage efficiency in buildings continue to garner legislative support. As public focus remains on efficiency, demand for these tools may rise on a wider range of projects than just green buildings.

HIGH-ACHIEVING GREEN BIM PRACTITIONERS

Green BIM practitioners who report achieving more than 50% of the overall potential of BIM (see page 8) also tend to simulate building and energy performance more frequently than the total group of Green BIM practitioners cited above:

■ Total Building Performance Simulation:

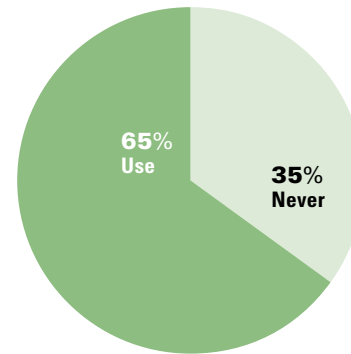
- 86% simulate whole building performance.
- 63% of those performing simulations do so on more than one quarter of their buildings—compared to 33% of all Green BIM practitioners

■ Energy Performance Simulation:

- 83% simulate energy performance.
- 69% of those performing simulations do so on more than one quarter of their buildings, compared to 38% of all Green BIM practitioners

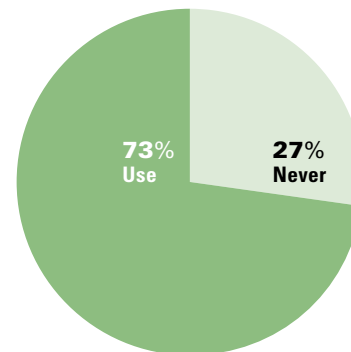
Use of BIM to Simulate Total Building Performance (among Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010



Use of BIM to Simulate Energy Performance (among Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010



CONTINUED

Building Performance and Energy Modeling

Frequency of Simulating Building and Energy Performance

CONTINUED

GREEN BIM DATA

This result suggests that as users continue to increase their knowledge and use of BIM, building and energy simulation within the models should be used more widely.

NON-GREEN BIM COMPANIES

Firms that do not use BIM on green projects largely have not adopted these tools for simulation purposes:

- **Total Building Performance Simulation:**
22% perform simulations in the model.
- **Energy Performance Simulation:**
21% perform simulations in the model.

Aspects of Energy Performance Most Frequently Simulated

Most Green BIM practitioners simulate multiple aspects of the building in order to gauge energy performance. Some aspects are simulated by a larger percentage of

Green BIM practitioners compared to those who report doing energy simulations as a whole. The large number of tools employed to understand energy use indicates the complexity of energy consumption in buildings.

Percentage of Green BIM practitioners who simulate the following building aspects to gauge energy performance:

- **Lighting and Daylighting Analysis:** 74%
- **Whole Building Energy Use:** 72%
- **Energy Code Compliance:** 70%
- **Product Qualification & Selection:** 64%
- **Renewable Energy:** 63%
- **Natural Ventilation Analysis:** 57%

Fewer than 20% of non-Green BIM companies engage in any individual simulations. However, of these the most common aspect simulated by non-Green BIM companies is whole building energy use, followed by lighting and daylighting analysis.

Satisfaction with Current BIM Tools for Energy Performance Simulation

Over one-third of all Green BIM practitioners (36%) have high or very high satisfaction with the BIM tools they use for energy performance. Another half of the respondents have medium satisfaction.

It is striking that more than twice as many Green BIM practitioners report a high/very high level of satisfaction as those that report low or no satisfaction with their tools (14%). This finding suggests that the current tools available for energy performance are meeting the expectations of their users.

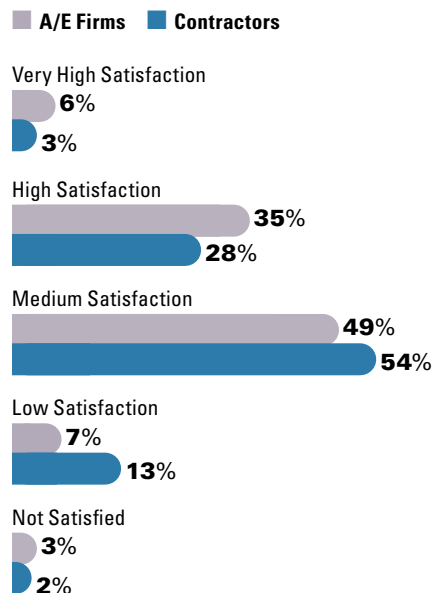
Variation by Firm Type

While roughly similar, A/E firms are slightly more satisfied with their tools than contractors:

- A/E Firms: 41% highly satisfied
- Contractors: 31% highly satisfied

BIM User Satisfaction with BIM Tools for Simulating Energy Performance (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Reasons for Not Using BIM for Energy Performance Simulations

There are a number of factors that impact the decision not to use BIM for energy performance simulations. They vary by firm type.

A/E FIRMS

The lack of the appropriate tools, the lack of required functionality and the perception that they do not need to do energy analysis are all reasons design firms are hesitant to use BIM in energy performance simulations—and all at equal levels of 48%.

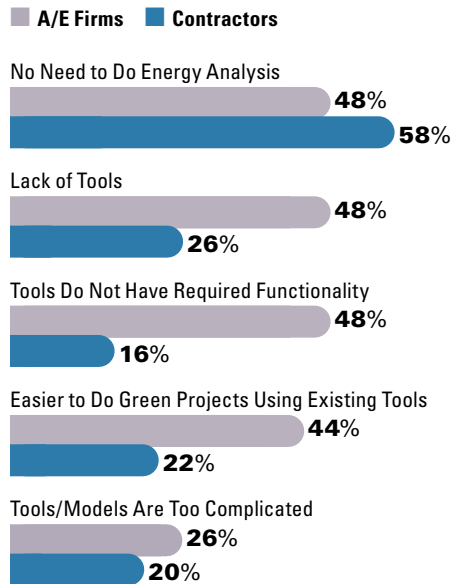
CONTRACTORS

The largest percentage of contractors who do not perform energy simulations (58%) do not believe they have a need to do any energy analysis. Since the current energy analysis tools can achieve more significant improvements and are more cost-effective to use in early design phases, contractors, who use BIM tools later in the process, are less likely to perceive energy analysis as essential or applicable to their green building work.

However, the availability of good, easy-to-use tools does impact the contractors. Roughly one quarter report the lack of tools (26%) and the ease of using their current, non-BIM tools (22%) as reasons they have not yet begun to simulate energy performance in BIM.

Influence of Factors Behind Non Use of BIM for Energy Performance Simulations (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Simulating Energy Performance in Two Years

Both Green BIM practitioners and non-Green BIM companies anticipate doing energy performance simulations in a BIM model on a much larger percentage of their total work within two years.

- **Green BIM: 80% will simulate energy performance on more than one quarter of their projects, compared to 28% currently.**
- **Non-Green BIM: 35% will simulate energy performance on more than one quarter of their projects, compared to 1% currently.**

The dramatic increase is likely influenced by several factors, including the general expectation of using BIM models for more projects overall as well as expecta-

tions that the available tools will improve, particularly for meeting the specific needs of green design and construction.

Other factors that may contribute to this increase include changes to LEED in 2009 that place greater emphasis on energy performance and potential carbon pricing impacts, which are expected to increase energy-efficiency in buildings as well.

Aspects of Energy Performance Expected to Be Simulated in Two Years by Current Non-Green BIM Companies

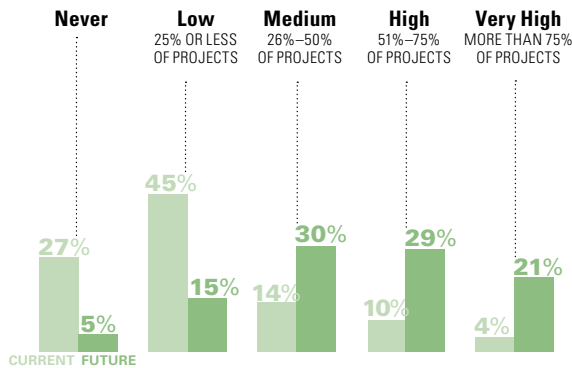
Most of these areas are already being simulated by Green BIM practitioners on some of their projects. Therefore, the explosion in the use of energy performance simulation in BIM models lies with the firms that are not currently using BIM for green projects.

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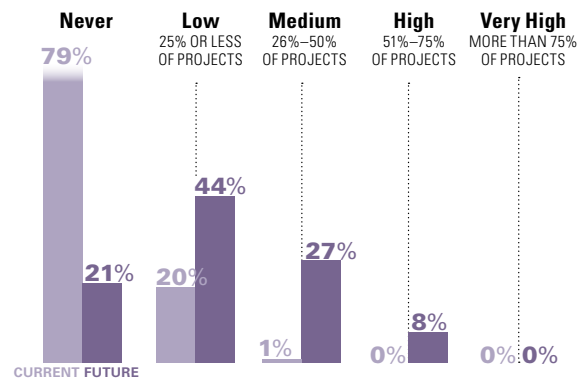
Current/Future Use of BIM to Simulate Energy Performance

Source: McGraw-Hill Construction, 2010

Green BIM Practitioners



Non-Green BIM Companies

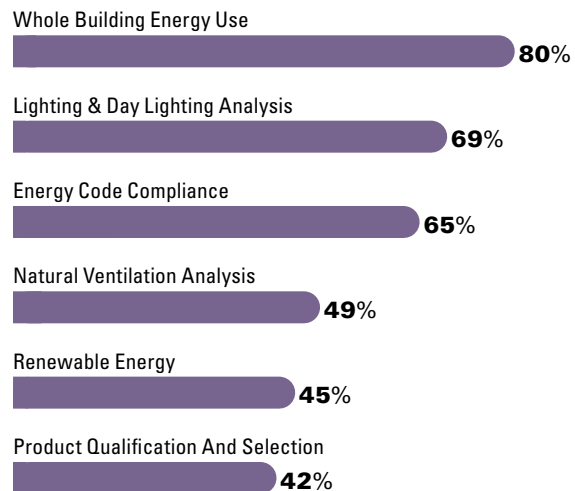


Fewer than 20% of non-Green BIM companies currently report simulating particular aspects of the building for energy performance (see chart at right for list). However, in two years, more than 50% of these firms would like to be simulating energy use in BIM in several areas:

- 80% want to simulate whole building energy use.** This broadly-held intention, despite the inherently complicated nature of whole building analysis, underscores the increasing importance of energy savings to green building.
- 69% want to simulate lighting and daylighting analysis.** Taking advantage of natural light not only reduces the need to use unnecessary interior lights but also provides a strong connection to the outside. However, heat gains from light impact building energy use. Modeling tools help designers balance these two issues in early design.
- 65% want to simulate energy code compliance.** Concerns about climate change are leading to more restrictive codes that must be addressed in new buildings and major renovation projects.

Aspects of Energy Performance Firms Would Like to Simulate in Next Two Years (according to Non-Green BIM Companies)

Source: McGraw-Hill Construction, 2010.



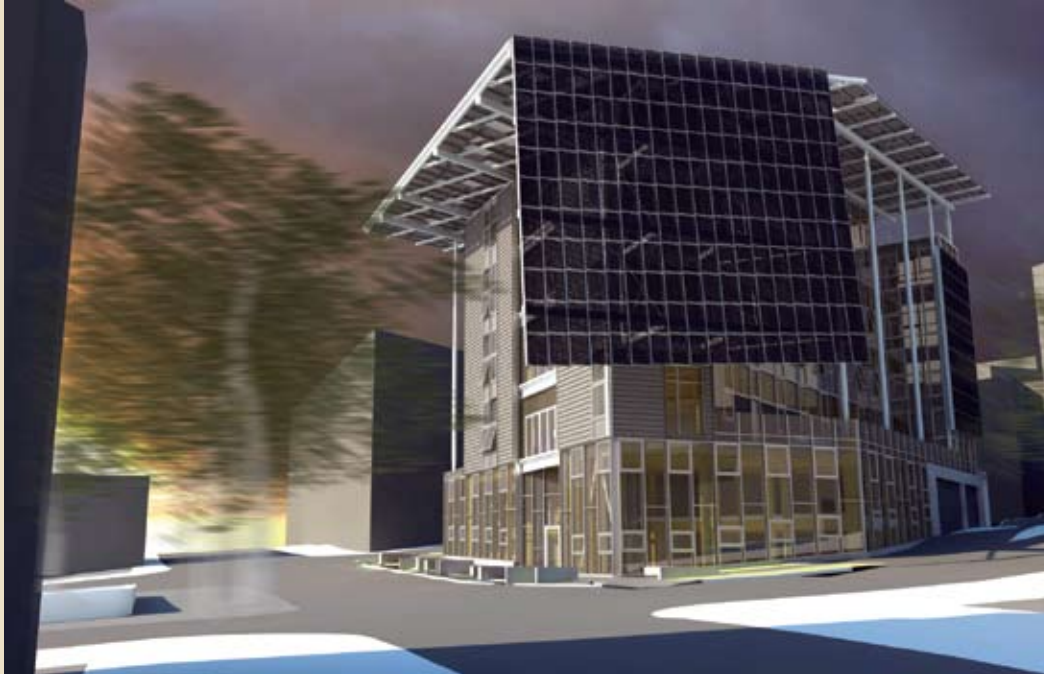
Desired BIM Simulations

When asked what they would like to simulate that they currently cannot, most respondents focused on cost simulations, better energy modeling tools, better lighting/daylighting analysis, HVAC modeling tools and water simulations.

As this industry evolves, tools will need to be better able to address these fundamental issues to achieve the growth potential suggested by the results above.

Simulating Building Performance

GREEN BIM



Cascadia Center for Sustainable Design and Construction

© The Miller/Hull Partnership

The potential to simulate building performance using BIM is among the emerging technology's most promising aspects. A vast majority of BIM users would like to see tools that help simulate whole building energy use and work seamlessly with a central model, although they are used for those purposes on only a small percentage of projects today. As these tools develop, many firms are devising ways to share data between their BIM models and energy modeling programs.

Requiring Integration of Energy Modeling within BIM Process

Some design firms that are able to fully integrate architectural and engineering tasks are out in front with the trend. SHP Leading Design of Cincinnati integrates energy modeling within its BIM process on

nearly every project that its in-house architects and engineers work on together. Aaron Phillips, director of technology and BIM services at SHP, says that after the company converted all of its architects and MEP engineers to Revit in 2004, it began to push its consultants to follow suit, but when that wasn't possible, the staff would often conduct its own basic energy analysis.

"In the beginning, when we would do an architectural project in-house and the engineering portions of it were out of house, we were still, as architects, doing energy modeling from a standpoint of iterative design, such as the orientation of a building, massing, percentage of glazing and things of that nature," he says. "Then the engineers provided the more finite detailed energy analysis, sometimes using the model, sometimes not, depending on what software they were using and what

integration problems there were."

Eventually, the firm mandated its use among its consultants. "We got to the point where we said, 'All right, we're 100% Revit; now you're 100% Revit, or you don't work with us,'" Phillips said.

Challenges of Existing Tools

Phillips says the firm has since adopted a standard energy modeling workflow. Starting with its Revit model, data flows to Green Building Studio, back to Revit, then to Ecotect Analysis and on to eQUEST. Although the firm is committed to its BIM-centered process, Phillips admits that it is not seamless. However, over time the firm has developed workarounds.

"Unfortunately, with most energy modeling software, you're going to have to cheat the system sometimes because the types of systems that

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we spec, install and measure are becoming more and more complex, and our software manufacturers are just not keeping up with having their systems in the software we use," he explains. "We do have to fudge the system to mimic the results of those systems, but we've done it enough to know where the hiccups are, what the workarounds are, what results we can bet the bank on and what results we can't bet the bank on."

The Need for Interoperability

The process of getting various energy analysis software programs to work together can be limiting for some users. For The Miller Hull Partnership in Seattle, energy analysis has been a critical part of its Cascadia Center for Sustainable Design and Construction project, which is set to begin construction in late 2010. The urban in-fill project is aiming for net-zero energy and water use. Brian Court, associate at Miller Hull, says the project has generated

"We definitely have to [conduct energy analyses] if we're going to create buildings that are designed with performance criteria in mind, and there's a real need for effective tools to accomplish that."

—Brian Court, associate, Miller Hull Partnership

multiple models, including Revit, Ecotect and eQUEST. However, those models are not always able to exchange data.

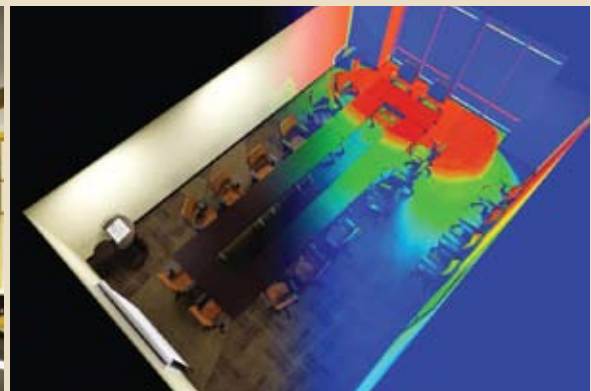
"The lack of a fully integrated approach can be frustrating," he says. "I feel that the true promise of BIM isn't really there yet. We're still in those early stages where it can be cumbersome."

A critical portion of the work done in the modeling software involved balancing maximal use of photovoltaic panels to provide solar energy with daylighting needs. Miller Hull imported an architectural model from Sketch-Up into Rhino. It then used Grasshopper to manipulate the photovoltaic array shapes, sizes,

slopes and orientations. These variations were brought back into Sketch-Up for shading and massing studies, and then Ecotect was used for daylighting studies.

Although the firm has not yet refined the process within its BIM models, Court says he expects such projects to push demand for improved interoperability.

"We're walking a fine line now between the mechanical engineers' scope and the architects' scope," he says. "We definitely have to go there as architects if we're going to create buildings that are designed with performance criteria in mind, and there's a real need for effective tools to accomplish that." ■



Technical College community room rendering showing daylight analysis (above); Cascadia Center for Sustainable Design and Construction (left)

Left to Right: © The MillerHullPartnership; © SHP Leading Design

Daylighting

As the uses of BIM for green buildings have evolved in recent years, daylighting analysis has emerged as an early benefit for many BIM adopters. Among those who use BIM for sustainable design, the vast majority conduct lighting and daylighting analysis with BIM and BIM-related tools. For architects, this provides the opportunity for a more effective and robust iterative design process that can drive more informed choices regarding a building's performance.

"Having these tools is invaluable when we go into conversations

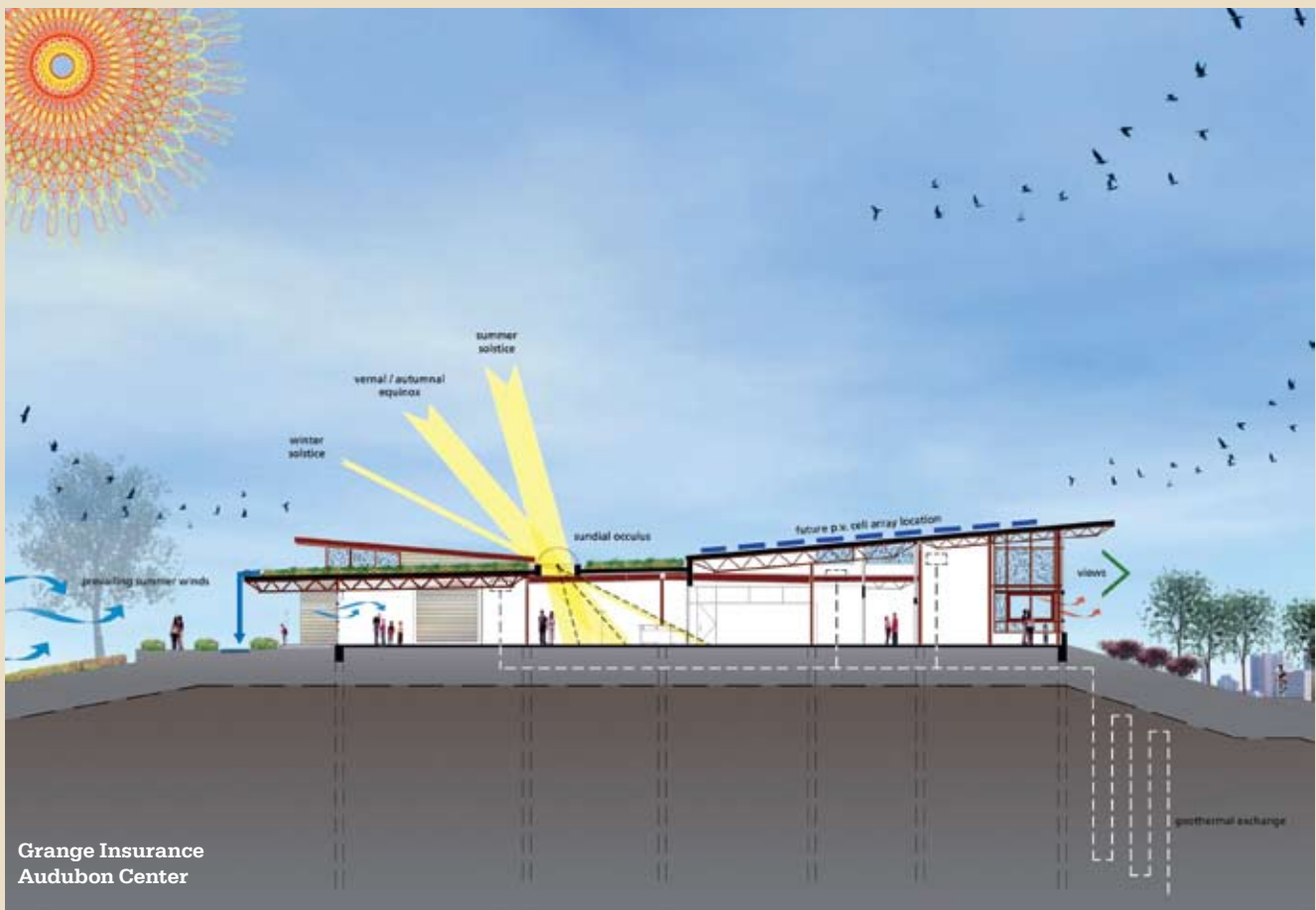
with clients or other [team members]," says Tom Turkington, project manager with KMD Architects in San Francisco. "If someone suggests a change, we can more easily show how it will impact [a project's] sustainability. We can say, 'Look, if you remove these pieces then you're not going to get the same effect of daylighting. You're going to use more artificial lighting, which is going to use more energy, which is going to endanger your LEED status.'"

Turkington says the process of modeling to show how changes could affect sustainability has been significantly accelerated through

energy analysis tools that work in conjunction with BIM. "What used to take weeks now takes days or maybe just hours," he adds.

Tools Help Maximize Daylighting

The firm has been sharing modeling data for daylighting analysis for nearly a decade. On the 277,000-sq-ft San Francisco Public Utilities Commission project, which KMD began designing in 2001, the team initially did its daylighting modeling in Google SketchUp, then brought those results into Revit. The firm has since adopted Ecotect Analysis



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for daylighting modeling. Through its analysis of the project, which is aiming for LEED Platinum certification when it is completed in 2012, the team established a maximum lease depth of 60 feet to maximize daylighting and exterior views. Light shelves were also strategically placed to help minimize solar heat gain and maximize daylight penetration.

Enabling Creativity

While BIM tools for daylighting have allowed some firms to improve the communication process with team members, they have also helped push creativity. By spending less time inputting data, more time can be invested in actual design, says Brian Skirpac, associate and BIM technology manager at DesignGroup in Columbus, Ohio.

"It opens up experimentation," he says. "As you start trying things out, new ideas come up because you realize you can play around and see what works. It generates excitement. Everyone adds more ideas to the mix."

"Having these [daylighting analysis] tools is invaluable when we go into conversations with clients or other [team members]."

—Tom Turkington, project manager, KMD Architects

Sun Studies Enable Passive Design & Signature Elements

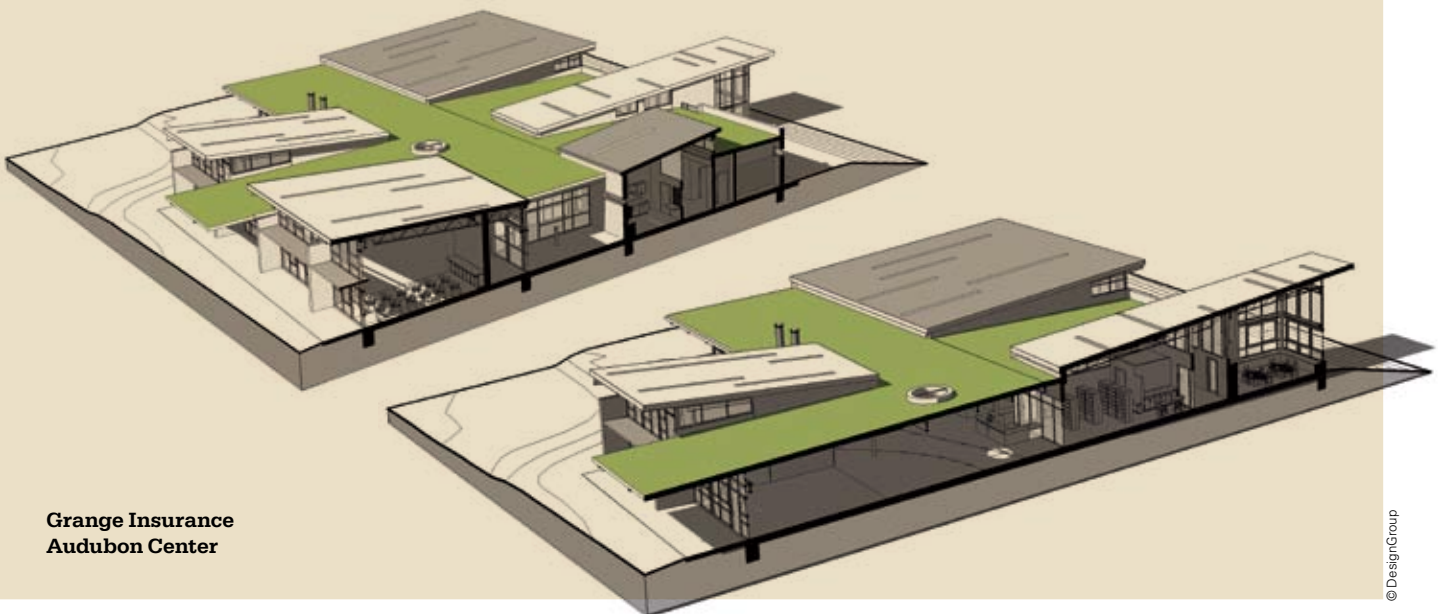
For the 18,000-sq-ft Grange Insurance Audubon Center in Columbus, which opened in August 2009, the team used BIM to help orient the building along an east-west axis to maximize sunlight exposure. With an emphasis on passive solar design, the firm created models to study how sun angles would affect both heating and daylighting, helping the team design more accurate window shadings and roof overhangs.

The team then drew ideas from those sun studies to add a signature design element to the building. A rooftop oculus was designed to cast a shadow on a sundial on the floor, which accurately shows the vernal and autumnal equinoxes as well as the summer and winter solstices.

Existing Buildings

Skirpac says the speed and versatility of daylighting analysis for iterative design has also been helpful for renovation projects.

"[Daylighting] has become a really easy analysis to look at," he says. "When we have projects where we go back to look at an existing building, it's much easier to think about the retrofit possibilities. We can easily look at whether or not it would be worth it to redo a lighting layout that includes daylight sensors. We can validate those kinds of design decisions and express the value of them to the owners." ■



Grange Insurance Audubon Center

© DesignGroup

Interview: Thought Leader

GREEN BIM



Steve Selkowitz

on the effort to improve BIM tools for green building

**Department Head, Building Technology Program
Lawrence Berkeley National Laboratory**

As department head of the Building Technology Program at Lawrence Berkeley National Laboratory in Berkeley, Calif., Steve Selkowitz leads a nearly 250-person effort to research all aspects of energy use in buildings. He is also the former vice chair of the International Alliance for Interoperability (IAI), now known as buildingSMART.

As an early member of IAI, how did you envision BIM could be used as a tool to improve energy efficiency?

SELKOWITZ: Fifteen years ago, my focus was: Why aren't energy issues addressed more frequently and effectively in building design? One answer was that the tools you'd use to address some of the energy modeling require a lot of data input, and that data is not typically available.

When a consultant gets a \$20,000 budget to do energy analysis, they might waste \$15,000 getting the CAD files that describe the geometry and laboriously input them into whatever separate format the energy tool requires. By the time they've done that and it's representative of the building when modeled, they've got \$5,000 left in the original budget, and they don't get to do much energy analysis. Then, months later when they're doing value engineering and someone says, "Let's take out the shading system, it looks like it costs too much," and someone asks, "What effect will that have on performance?," the consultant will have

"The vision we have is a world with an interoperable BIM that in minutes allows you to take your current architectural design from your favorite platform [and analyze it in] your favorite energy program..."

to go back and change the model, which might take a week and cost \$10,000. If the client doesn't have the time or the money, you cross off the shading system and proceed.

The vision we have is a world with an interoperable BIM that—in minutes rather than days or weeks—allows you to take your current architectural design from your favorite platform, import it into your favorite energy program and do your analysis. Your consultants within a few hours of work—rather than a few weeks—now can work as a team on energy alternatives and optimization. Then that meager budget can be much more effectively deployed.

How has BIM evolved as a green tool?

SELKOWITZ: There's enough accomplishment out there to show that the potential is real and important, but it's still frustratingly out of reach if you want it to be routine, solid and working every time. To get to the point where everyone is using it and we're changing the way buildings are built, it needs to be usable by the average designer without a huge amount of extra effort. At the moment it's one of those things where people who put in the extra time and effort can make it work, but it's a bit tricky and painful.

Why has that been such a struggle?

SELKOWITZ: People say the vision is the right one, but the implementation—rather than it being driven by a powerful central group with an open standard—was driven by the proprietary standards that each of the major vendors had or has. It was logical in the sense that the building process starts with design, then the vendors have each of their own BIMs and their own way of structuring and organizing the building. It was logical that they proceed that way.

What would accelerate the process?

SELKOWITZ: Mandates. If a big owner mandates that something will happen, that tends to push the vendors or other owners. It's the free market forces that tend to be painfully slow in most cases. Already more large organizations are asking for BIM because they see value here. And there are organizations that want to be green or are forced to be green. There's a connection between the two. If you made the leap to be more green, then you'll be dealing with more data and more analysis. If an owner wonders how they can do this more efficiently and BIM offers that solution, that is a reinforcing factor. ■

BIM and Green Building for Contractors

Many contractors have adopted BIM to save time and money on projects. However, many are discovering that the same strategies can also improve a project's sustainability.

While the ultimate goal of green building is to produce high-performance facilities, sustainable practices are at work during construction as well. By using building information modeling, many contractors realize efficiencies that can reduce material waste and resource consumption to improve the overall carbon footprint of a project.

"We think of ourselves as a sustainable business because of how we apply BIM," says Dace Campbell, integrated delivery specialist for BNBuilders in Seattle. "Our goal with BIM is to save time and money. In doing so, we cut back on waste. That could mean using less material or saving the fuel used to transport materials or reducing the impact of rework. By being efficient, our footprint is reduced."

Campbell says the net effect of construction efficiency on sustainability is often overlooked because it does not easily translate into points for green ratings systems.

"The goal is to cut back on waste, but how do you measure what didn't take place?" he muses. "We can make the case to owners that being efficient saves money, but if that doesn't get you LEED points, [the green aspect] is easily overlooked."

Enabling Prefabrication and Modularization

By using BIM to design and plan projects with more predictable

outcomes, contractors are more comfortable using techniques such as prefabrication, preassembly and modularization, says Derek Cunz, vice president and general manager at Mortenson Construction in Minneapolis.

"As we have our buildings built virtually with more and more detail, that puts us in a position to drive a lot more things like modular construction," he says. "At the beginning of the BIM wave, it started with things like prefabrication of structural steel or ductwork. Now, we're looking at more subassemblies and groups of subassemblies."

Cunz says that Mortenson is increasingly using BIM to create modular components, such as headwall assemblies and bathroom assemblies.

"We bring together chunks of interiors rather than stick-building them on site," he adds. "It's as green as you can get when you're not using all of that raw material and creating waste."

Cunz also contends that modular pieces can often be more efficient than those built in the field.

"The quality of an enclosure is a huge driver of energy efficiency," he says. "So much energy is placed on the performance of the building systems, but if your enclosure is not high-performing, you lose a lot of that benefit."

Energy Modeling & BIM

Although contractors and engineers

can add significant detail to BIM models today, the potential to use that information for improved building performance is often wasted, says John Tocci, Jr., virtual construction manager for the western region of Gilbane Building Co. in Phoenix. In addition to creating construction models for projects, Gilbane also does in-house energy modeling of projects to help ensure quality control. However, Tocci says, the team has to "dumb down" its models to make them work with most energy modeling software.

"Our experience is that the actual BIM model contains more information than an energy model can understand or handle," he says.

Tocci says that to get a useful energy model of the exterior skin of a building, his modelers remove multiple elements such as precast panels, curtainwall systems, mullions and multipaned windows, and a roof has to be made completely flat.

Tocci says that the detail provided in BIM models by contractors could ultimately improve the accuracy of energy modeling, but today it is a missed opportunity.

"We can make it work, but it's not something you can expect to do in an hour," he says. "It's something where you say, 'Let me roll up my sleeves and clear my schedule.' Consultants have told me that sometimes it makes more sense to just start the energy model from scratch. That's waste that needs to be taken out of the process." ■

Data: Monitoring Building Performance:

Green Operations & Maintenance

GREEN BIM DATA

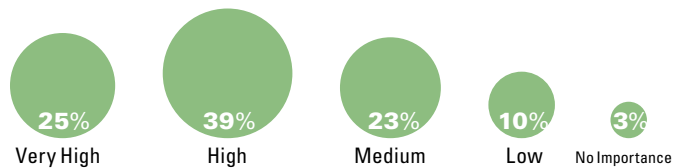
Importance of Verifying Building Performance Against Green Design Targets

Verification that building performance matches green design goals is currently one of the most important challenges in green construction. **64% of Green BIM practitioners and 59% of non-Green BIM companies surveyed attach high importance to verifying that building performance corresponds to the targets identified in design.** In fact, one quarter of firms using BIM on green projects regard building performance verification as of very high importance.

The ability to deliver performance verification has strong implications for A/E firms and owners as they pursue green outcomes. Matching design strategies with verified results will allow A/E firms to refine their green building strategies, and owners can track quantifiable returns on their investment, which could in turn lead to even higher levels of green building investment.

Importance of Verifying Building Performance during Design (among Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



Ideal Interval for Monitoring Green Building Performance

While most agree that monitoring performance is critical, the industry has no clear predisposition toward a specific interval at which buildings should be monitored. The firms engaged in Green BIM are closely split between annually, every 2 years and every 5 five years.

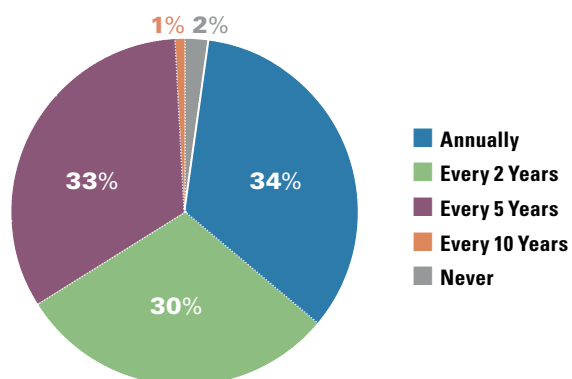
The lack of agreement may reflect two different motives behind industry's engagement in monitoring building performance:

- Building performance should be monitored frequently to make sure the building achieves green goals.
- Building performance monitoring should be balanced against cost benefits to maximize building savings with minimal operations investment.

The close correspondence of the split between Green BIM practitioners and non-Green BIM companies regarding the ideal monitoring interval suggests a lack of overall industry consensus about the best tactical approach to take in order to achieve optimal building performance during operations versus something specific to green building.

Ideal Frequency of Green Building Performance Monitoring (according to BIM Users)

Source: McGraw-Hill Construction, 2010



BIM Contribution to Monitoring Sustainable Performance

Green BIM practitioners recognize the strong potential BIM offers as a tool for monitoring building performance in the operation phase.

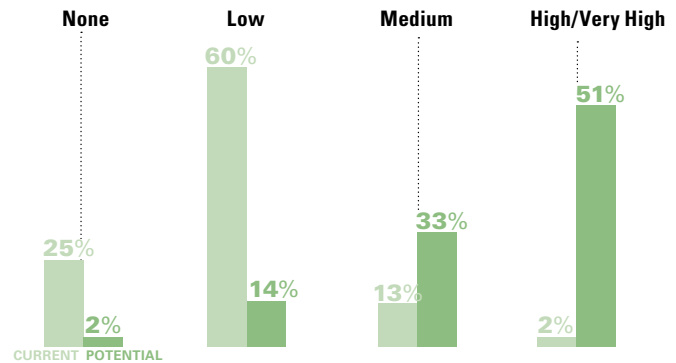
More than half (51%) of Green BIM practitioners believe that BIM has a high long-term potential contribution to monitoring sustainable performance. By comparison, only 2% see it as having no contribution and only 14% perceive it having low value.

As mentioned on page 9, building performance monitoring and performance is starting to be mandated, both in the new LEED 2009 requirements and in recently passed regulations in Washington, D.C. and New York City. Market pressure around this issue may increase as other cities, including Boston, consider adopting similar legislation to encourage private industry to improve building energy performance.

Given these factors and the strong potential contribution of the BIM tools (according to Green BIM practitioners), growth in the use of BIM for monitoring is likely to increase in the future, potentially at dramatic levels.

Contribution of BIM to Monitoring Sustainable Performance of Buildings: Current and Potential (according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



Owner Awareness of BIM and Access to Models

Educating owners about the value they receive from modeling their buildings in BIM is needed—most of the industry agree that owners in general have a low awareness of the benefits of BIM.

■ Green BIM Practitioners:

- Low Owner Awareness—59%
- No Owner Awareness—7%

■ Non-Green BIM Companies:

- Low Owner Awareness—58%
- No Owner Awareness—20%

Given the importance client demand has on BIM adoption levels, actively engaging owner awareness through education and outreach around the benefits of BIM is a critical strategy for wider adoption of BIM in general, and of Green BIM in particular. Educational efforts that specifically demonstrate the financial benefits of BIM as well as potential operations and maintenance efficiencies may be particularly successful for the owner audience.

Influence Factors to Encourage Owner Awareness and Adoption of BIM

62% of Green BIM practitioners believe case studies that demonstrate bottom-line benefits for owners would be a highly influential strategy for encouraging owner awareness and adoption of BIM, again underscoring the critical need for owner education.

55% of Green BIM practitioners also affirm that making BIM compatible with building control system software packages would strongly influence owner adoption of BIM. Greater usability is thus another critical factor for increasing owner involvement with BIM.

Other influence factors include enacting performance and tracking related codes and legislation (44%) and engaging owner organizations (43%).

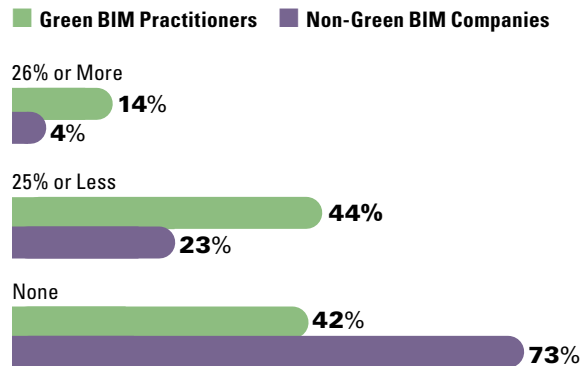
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Percentage of Firms that Supply BIM Models to Owners

At this point, providing the owner with a BIM model for monitoring building performance is not a common practice. Among firms using BIM for green projects, 42% do not provide models to any owners, and 44% provide models to 25% of their owners or less. However, Green BIM practitioners more frequently provide owners with models than non-Green BIM companies, suggesting that owners are more often involved with BIM on green building projects.

Percentage of Owners Provided with BIM Models

Source: McGraw-Hill Construction, 2010.



The Promise of BIM for Improving Facility Management

Birgitta Foster, BIM champion at Sandia National Laboratory in Albuquerque, NM has been an active advocate in the industry for the changes needed to fully achieve the use of BIM by facilities managers since she was first introduced to BIM five years ago. She explains several strategies to increase the value of BIM for building owners and facility managers.

BIM is often used as a tool that enables integrated design. Foster notes that integrated design should include facility managers. She asserts that we need to “start looking at design for maintenance, not just design for construction.” She argues that it is counterproductive to budget and design for “the first two years of the building and not consider 50 years of impact ... [facility managers] need to educate designers, and the only way to do that is bring in the facilities people early on and have them share their insights.”

Foster also believes that building owners and facility managers

need to determine the key data contained in the BIM that would aid facility management and focus on how to collect and manage them within current CAFM (computer aided facility management) systems. According to her, building owners need to “decide what information they want, not only to manage, but to maintain.” For her, the data inside the model is the core piece that will help them manage the building better.

However, in order to access that data, there needs to be improved interoperability between CAFM systems and BIM systems. Foster believes the best way to achieve this is for the CAFM designers to adopt an open standard that can interact with any of the BIM programs. She contends that designers should choose the tools that work best for them, and her CAFM system should be able to pull data from any program the project team has chosen.

Foster notes that one valuable use for the data stored in BIM is

to train the maintenance people about the systems during the design and construction process. “When the building comes on line and they take over, they are very, very familiar with it because they have been working with the model and understand all the systems.” She compares that to the inefficiencies of the current method, which she characterizes as “Here’s the keys, go figure it out, and here’s your big stack of O&M manuals.”

Work on a building is continuous and does not end with construction. Foster notes that one advantage BIM offers is the ability for facility managers to continue to optimize the building. She wants to be able to use BIM to measure whether the owner has achieved the return on investment promised in the design and construction of a green building and to make improvements throughout the building’s lifecycle that increase building performance.

Interview: Thought Leader



Charles Matta

on GSA's outlook on the role of BIM in green building

**National Director, Strategic Programs & Professional Resources,
U.S. General Services Administration**

The U.S. General Services Administration (GSA) faces multiple mandates in the coming years to cut its energy consumption, and BIM is seen as a tool to help fulfill that mission. In 2010, GSA facilities must use 55% less fossil fuel energy than the average commercial building. By 2030, all new GSA facilities must be net-zero carbon energy buildings. Last year, the GSA released the first draft of the "GSA BIM Guide for Energy Performance" and is currently creating a BIM guide for operations and maintenance with a strong focus on sustainability.

How do you see BIM helping GSA achieve its aggressive green goals today?

MATTA: Our administrator [Martha Johnson] is pushing for a zero environmental footprint, which is a very tall order that cannot be achieved without the use of BIM. Two things will be at play: the integrated design achieved through BIM and the integrated building systems. These two have to flow from one to the other and work hand-in-hand to achieve these goals.

The commissioner of the Public Buildings Service [Robert Peck] is pushing for a green proving ground. He wants us to experiment with new technologies that will help improve sustainability and energy use in our facilities. BIM helps achieve the front end of it, early in the planning and design and in the construction

component, specifically BIM energy analysis and daylight analysis.

We're aiming at more accurate predictions during early design phases. That helps us understand how a building and its users consume energy and allows us to make more informed decisions. Mechanical engineers for a long time have been doing some form of energy analysis predictions, but BIM allows us to do it more accurately with better assumptions. We use the architect's model more and more to squeeze out those last bits of energy savings leading to better, faster design and analysis.

What are the top benefits of BIM in green building?

MATTA: Traditionally, before BIM, the engineer would look at a building block, assign a perimeter and a core and do the analysis based on the two. With BIM, we do space-based analysis that applies the occupancy for each room and other components that in the past were very vague, general assumptions. Now, you achieve a greater level of granularity and insight into the design, and at that point you start to influence the development of the design based on the readings from that energy model.

What challenges do you face and how are you addressing them?

MATTA: Interoperability. It is difficult to translate a design model into an energy model with the current software. That is something that, as we are defining the modeling

standards, we'll be able to achieve much faster, better and more smoothly. The way we look at it is, can we afford not to do this, especially with the goals established under the executive order and our internal goals?

Our push toward having a better transition through modeling standards will greatly help through incremental improvements that are based on more accurate simulation. The modeling standards that we are working on go a long way toward making it more seamless.

How do you envision BIM factoring into your green mission in the future?

MATTA: We have over 1,500 GSA-owned buildings and, at best, we may build 20 per year. I see in the future more modernizations and fewer new buildings.

From a business model, BIM has to apply to the operations and maintenance of the facility. That is where we will get the greatest value. With integrated building systems, if there's any activity that's off in its output, we're able to compare that with the intent in the model and address that much faster than in the past. We're working on having a central sustainability command that would identify these potential variations that impact energy usage and notify the local team to address them immediately. This is in line with the flow between integrated design and integrated building systems. ■

Data: Using BIM for Green Retrofits

GREEN BIM DATA

Using BIM for Green Retrofit Projects

In today's economy, a large share of construction projects are renovation projects—approximately 61% of all projects in 2009 according to McGraw-Hill Construction data on construction starts. Therefore, the existing building market provides a significant opportunity for green design and construction activity.

In the *Green Building Retrofit and Renovation Smart-Market Report* (2009), McGraw-Hill Construction projected that the green share of the retrofit and renovation market would grow from 5%–9% by value in 2009 to 20%–30% by value in 2014.

Many BIM tools that are applicable to enhancing the performance of new buildings also apply to green retrofit and renovation projects, making this area a prime opportunity for the growth of BIM as well.

Future Use of BIM on Retrofit Projects by Non-Green BIM Companies

88% of all respondents who do not currently use BIM on green projects believe that their firm will use BIM on a green retrofit project in the next two years. Similar to the use of BIM for green projects in general, the majority of respondents (65%) believe that they will use it on 25% or less of all their green retrofit projects.

However, strong interest by those not currently using BIM for green projects suggests awareness in the industry at large of benefits BIM may offer retrofit projects.

Factors Influencing Increase of Green Retrofits

Contractors and A/E firms agree that green retrofits will increase if cost benefits and savings can be quantified.

IMPROVED ROI

Contractors in particular (70%) regard ROI as a highly influential factor for increasing green retrofit activity.

Contractors with experience in Green BIM believe it even more strongly.

- Contractors Practicing Green BIM: 72%
- Contractors Not Practicing Green BIM: 64%

65% of design firms also value improved ROI, which ranked second for design firms overall, and first among non-Green BIM design firms, at 74%.

BETTER ENERGY PERFORMANCE PREDICTION

The highest percentage of overall A/E firms (68%) consider better prediction of energy performance to be a key influential factor.

- A/E firms Practicing Green BIM: 67%
- A/E firms Not Practicing Green BIM: 71%

Energy performance accounts for the majority of financial benefits achievable in a green retrofit project, and capturing those benefits early through BIM modeling allows A/E firms to demonstrate the financial returns of various green strategies more effectively.

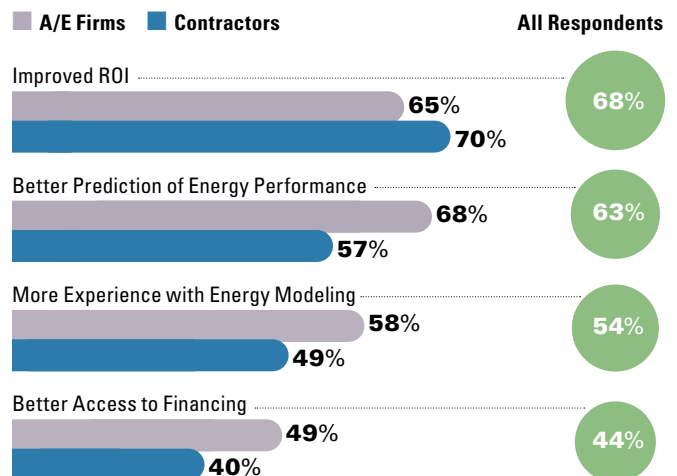
More than half of the contractors surveyed (57%) also recognize the value of better predictions of energy performance as a highly influential factor in the growth of green retrofit activity.

OTHER INFLUENCE FACTORS

A/E firms and contractors also consider more experience with energy modeling and better access to financing influential. The high level of reporting on multiple factors suggests there are a number of drivers of green building in existing building projects, and by extension, the use of BIM for these purposes.

Most Influential Factors Behind the Increase of Green Retrofit Activity (by Respondent Firm Type)

Source: McGraw-Hill Construction, 2010



Role of BIM in Meeting Sustainability Goals on Green Retrofit Projects

Most Green BIM practitioners believe that BIM will help them achieve sustainability goals on green retrofit projects—76% rate its applicability for these projects as medium or high. More than one third of that group (27% of the total Green BIM respondents) find BIM to be highly applicable for green retrofit projects.

FIRMS WITH BIM EXPERIENCE

Firms that use BIM on more than three quarters of their projects are even more enthusiastic—41% find it highly applicable to the retrofit projects they tackle. As firms' experience with BIM grows, so does their application of it for existing building projects. Therefore, as BIM adoption increases, so too should its use on retrofit projects.

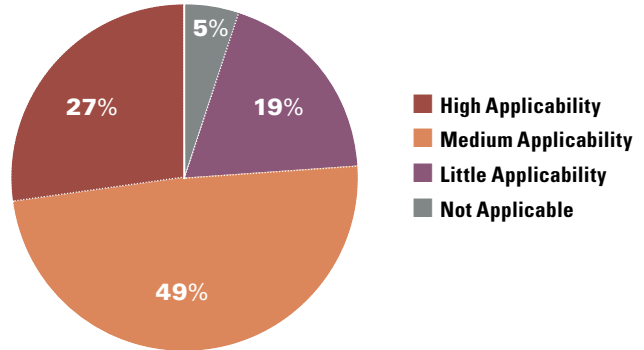
FIRMS THAT DO MINOR RENOVATION PROJECTS

In addition, 37% of the firms that work on minor renovation projects agree that BIM is highly applicable to green retrofits. This group is important because green retrofits can range from large, complicated projects to small, relatively simple jobs. The fact that more of the firms specializing in minor renovation projects value BIM for green retrofits, as compared to general Green BIM practitioners, indicates the need for greater industry-wide recognition that BIM is effective for small projects.

Value of BIM for Achieving Sustainable Objectives in Retrofit Projects

(according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



Data: Green Products and BIM

GREEN BIM DATA

Green Products

Green building products increase in number and availability every year, but 69% of respondents still report that finding green products represents at least a medium challenge when they work on green projects.

Importance of Green Products for Green Projects

Almost all firms consider green products important to green projects. Strikingly, 19% of firms rate the importance as very high. For the most part, the importance is relatively high whether a firm uses BIM for green projects or not.

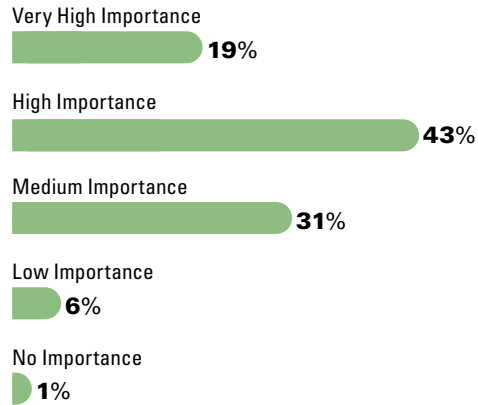
Lifecycle Assessment Linked to BIM

Lifecycle assessment is one measure of sustainability in products that is gaining in importance. This measure can be linked to BIM, but currently, even Green BIM practitioners are rarely linking it on more than 25% of their projects, and 47% never link it at all.

However, **48% of Green BIM practitioners state that it is highly important to have the ability to do lifecycle assessment with BIM.** Another 34% find this to be of medium importance. This strong response suggests that industry need should drive growth in BIM capabilities in this area.

Importance of Green Products to Green Projects

Source: McGraw-Hill Construction, 2010.



BIM and LEED Credit Calculations

The expected growth of Green BIM (see page 8) reinforces the correlation between the growth of the green building market and the growth in use of BIM tools. Therefore, as the green building market comprises a higher share of construction—new and existing—and as higher levels of energy efficiency become required in buildings, use of BIM is also expected to increase.

The LEED rating system has also seen tremendous growth in the marketplace, with LEED-registered projects increasing approximately 38% between 2008 and 2009 following a 78% increase between 2007 and 2008. This shift corresponds with more design and construction teams understanding the LEED system and knowing how to calculate and document credits.

Thus, the demand for tools to help project teams do their LEED documentation more effectively is already strong and should continue to grow, creating a new set of demands—and opportunities—for technology companies serving the market.

Using BIM for LEED Credit Calculation

Users of Green BIM are currently divided on how useful BIM models can be in calculating LEED credits.

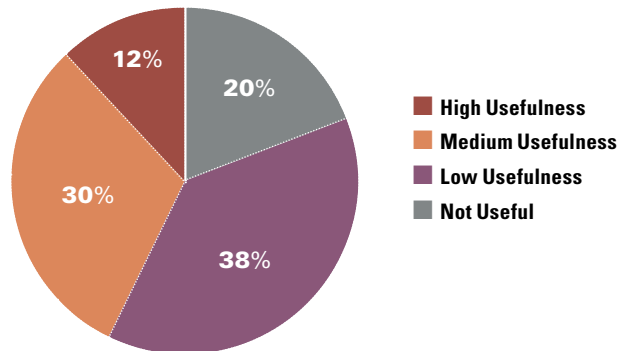
- 42% believe the technology has medium to high usefulness.
- 38% believe its usefulness is at a low level.
- 20% do not see its value.

How teams currently use BIM may in part account for the mixed opinions. Currently, BIM tools have been shown to be used for energy simulations, lighting analysis and other factors related to the energy use of buildings, but many early adopters of Green BIM are not using it for other aspects of whole building design, including water conservation modeling, which may increase with both a higher level of sophistication of LEED rating requirements and improved functionality of technology.

Additionally, the ways users are currently employing BIM on green projects may lead some respondents to report that its usefulness for calculating LEED credits is low. For example, firms may be using BIM models at the end of the project to determine the implications of the design rather than in the up-front stages where it would have optimal value.

Usefulness of BIM Models in Calculating LEED Credits (according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



CONTINUED

Automating BIM Model Data for LEED Credit Calculation

Currently, the market does not have a high level of automation in the process for applying data in BIM to LEED credit calculation, though nearly one quarter of respondents do report they have automation systems in place. This may contribute to the low level of usefulness currently perceived in application of BIM for LEED calculations.

It is likely, however, that the increase in Green BIM practice will require a corresponding increase in the use of BIM for calculating LEED credits or for helping determine how the building will achieve requirements of other building performance standards, such as local government or state policies. This will drive a need for automation.

Challenges of Using BIM for LEED Credit Calculations

42% of firms not currently practicing Green BIM are not using BIM for LEED Credit calculation because they find existing tools easier to use.

Another 36% do not believe they have a need. However, since there is a lower level of green building adoption by these firms (see page 22), the fact that they are not using it would be consistent.

Respondents also cite specific challenges with the tools themselves, suggesting need in the industry as a whole for models that can be used for LEED:

- 33% find there is a lack of tools.
- 28% believe they are missing functionality.
- 22% believe models are too complicated.

Value of a BIM LEED Calculating Tool

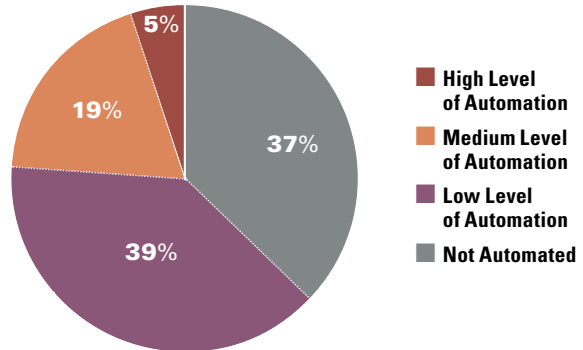
More than three-quarters (76%) of individuals who are currently practicing Green BIM believe having a BIM LEED calculating tool would be of at least medium value, suggesting a high market need for such a tool. Only 18% think it would have little value, and a very small percentage (6%) think it would have no value.

Notably, there were not significant differences between the opinions of those currently calculating LEED credits with data from BIM models versus those that were not, indicating a somewhat stable market need.

Level of Automation in Calculating LEED Credits through BIM

(according to Green BIM Practitioners)

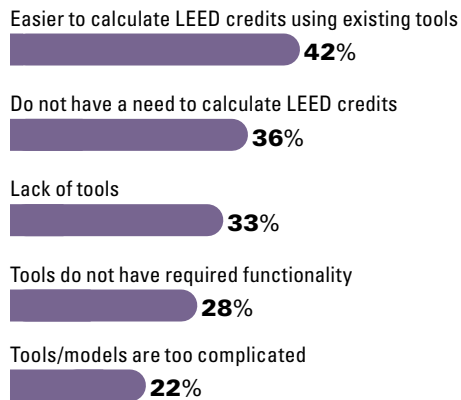
Source: McGraw-Hill Construction, 2010.



Reasons Behind Not Using BIM to Calculate LEED Credits

(according to Non-Green BIM Companies)

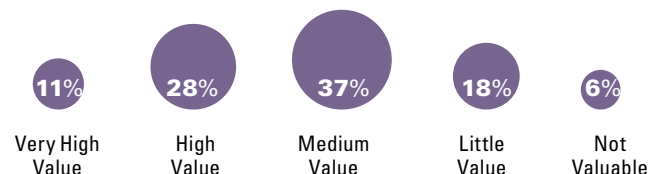
Source: McGraw-Hill Construction, 2010.



Value of BIM LEED Calculating Tools

(according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



The Intersection of BIM and LEED

BIM tools and the U.S. Green Building Council's LEED rating system are combining to create more sustainable outcomes in buildings today and have the potential for greater integration in the future.

The USGBC's Mike Opitz, vice president of resource development and Brendan Owens, vice president of LEED technical development, share their insights about how project teams that use BIM tools can more effectively achieve some of the green building practices and strategies promoted by the LEED rating system. They also clarify how the ongoing evolution of LEED will increase the benefits of using BIM for LEED projects.

ENERGY PERFORMANCE

According to Brendan Owens, "LEED is all about focusing on multi-parameter decision making to ensure people are optimizing buildings as systems rather than optimizing systems of buildings." While BIM tools do not quite allow for complete, holistic whole building optimization yet, Owens recognizes that BIM energy modeling tools, used early in the design process, allow designers to understand the implications of their decisions on the building's energy performance.

However, Owens reports, these tools are not always used to their full advantage. He describes how design teams will "use energy simulations as a compliance tool rather than as an iterative design analysis engine. You obviate the benefit of the energy simulation if you do it at the end, after you have made all the decisions."

Mike Opitz sees even greater potential if the tools evolve to provide

a more holistic view of how different elements in the design contribute to the building's overall performance. He would like to see energy modeling, daylighting analysis and other performance gauges brought together in "one easy-to-use package" and notes that progress has already been made toward that goal.

WATER CONSERVATION

While water conservation is another critical element of green building, it is far less likely to be modeled in BIM. Owens describes how water use credits in future versions of LEED will demand "a whole building/site water balanced view, asking people to look at the entire water flow through their projects, [including] rainwater management, potable water use, wastewater generation, process water and cooling towers." He asserts that "as the sophistication of the requirements in the LEED rating system evolve, you will start seeing [BIM] tools better built to serve that purpose."

INTEGRATED DESIGN

Opitz describes improved process as a common theme voiced by many successful project teams that achieve LEED certification: "We hear that process counts, process matters." Integrated design is one of the major process improvements that he notes. "One of the best practices that LEED embraces and leverages is the notion of getting everyone to talk at the

same time, about the same thing, at the right points in the process." The holistic view of building systems fostered by integrated design process enables strong sustainable outcomes.

BIM provides an essential tool that supports integrated design. In fact, Owens claims that "the main point of connection [between BIM and green building] is integrated design and integrated thinking."

MATERIAL ATTRIBUTES

Owens believes one benefit of BIM that should be more widely recognized is its ability to function as "the repository of all the material attributes that make up a building." He argues that a long-term focus on developing the capabilities of BIM in this area prevents the loss of information on the embodied greenhouse gas and chemical make up of building materials after the building is constructed.

LEED ONLINE AND BIM

The launch of LEED 2009 featured an updated version of LEED online. Opitz describes how that update provides the "underlying architecture that sets the stage to allow more automation of the project data." He explains their goal is to have future versions of LEED online that will allow project teams to have their BIM software automatically send in their data, rather than laboriously upload it into the system. ■

Data: Model-Driven Prefabrication

GREEN BIM DATA

BIM Model-Driven Prefabrication

Providing BIM models to building product manufacturers to prefabricate building elements off-site offers many green benefits, including the reduction of waste produced by onsite fabrication. Prefabricated elements can include complicated HVAC or electrical systems in buildings.

Increasing prefabrication also provides other advantages. In *The Business Value of BIM SmartMarket Report* (McGraw-Hill Construction, 2009), 71% of BIM users considered increasing prefabrication highly important to improve overall project ROI. In addition, prefabrication has been demonstrated to reduce the amount of time required for construction and to increase safety on-site at projects.

Current Reasons for Doing BIM Model-Driven Prefabrication

69% of Green BIM practitioners report saving time and money as the primary reason for engaging in model-driven prefabrication. A/E firms and contractors both predominantly value this reason for using BIM model-driven prefabrication.

Prefabrication is one of the strategies to achieve lean construction projects, a major driver of BIM in the industry. A primary goal of a lean approach is to prioritize time and money savings.

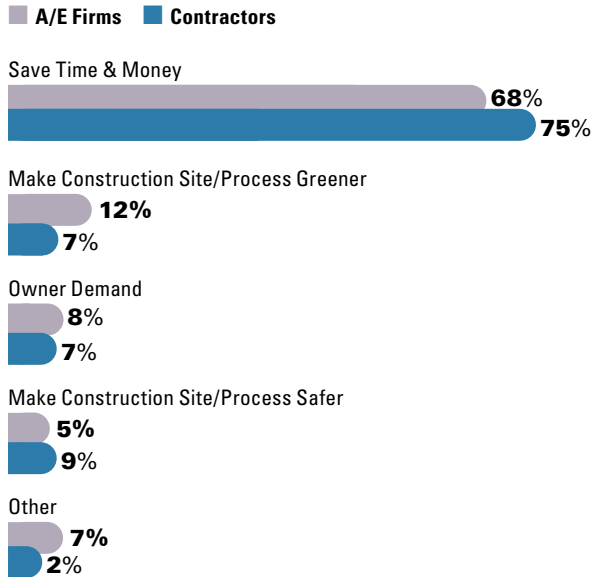
Other factors reported by Green BIM practitioners as the primary reason for doing model-driven prefabrication, though at relatively low levels:

- Making construction site/process greener: 10%
- Making construction site/process safer: 8%

Given the importance of saving time and money to all players involved in BIM, the fact that some portion of the industry feels the impact of prefabrication was most important in terms of making the construction site greener or safer suggests that there are other benefits BIM is expected to deliver.

Primary Reason Behind Use of BIM Model-Driven Prefabrication (according to Green BIM Practitioners)

Source: McGraw-Hill Construction, 2010.



CONTINUED

BIM Model-Driven Prefabrication Adoption in Two Years

Currently, the majority of both Green BIM practitioners and non-Green BIM companies are either not using BIM model-driven prefabrication or using it on a very low percentage of their projects.

In their two-year predictions, however, industry opinion shifts, with more players anticipating higher use.

HIGH LEVELS OF USE

Currently, only 16% of Green BIM Practitioners and 8% of non-Green BIM companies report engaging in model-driven prefabrication on more than 50% of their projects.

This increases significantly in two years to use by 42% of Green BIM practitioners and 29% of non-Green BIM companies.

LOW LEVELS OF USE

With the increase in high usage comes a corresponding decrease in low levels of use.

Currently, 63% of Green BIM practitioners and 77% of non-Green BIM companies cite low levels (use in less than 25% of projects) in the use of BIM models to drive prefabrication.

This shifts dramatically in two years when only 27% of Green BIM practitioners and 43% of non-Green BIM companies expect low levels of use.

VARIATION BY PLAYER

Contractors lead the design community in their expectations for future adoption of BIM model-driven prefabrication.

Expectation to use model-driven prefabrication on over 50% of their projects in two years:

- Contractors: 59%
- A/E Firms: 22%

Model-Driven Prefabrication and Green Construction

Most Green BIM practitioners see model-driven prefabrication as a moderate to high contributor to making a building and a project site greener.

■ Contribution Toward Greener Building:

- Medium: 45%
- High: 25%

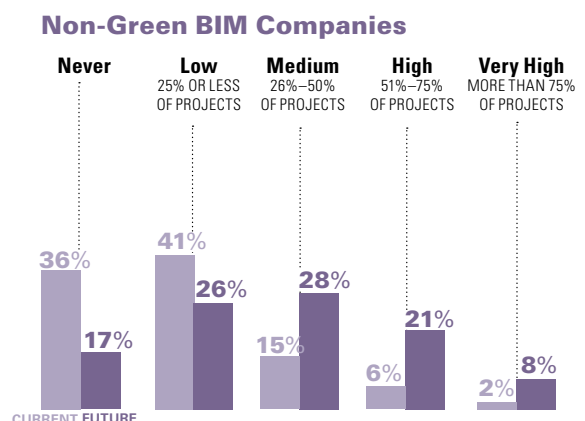
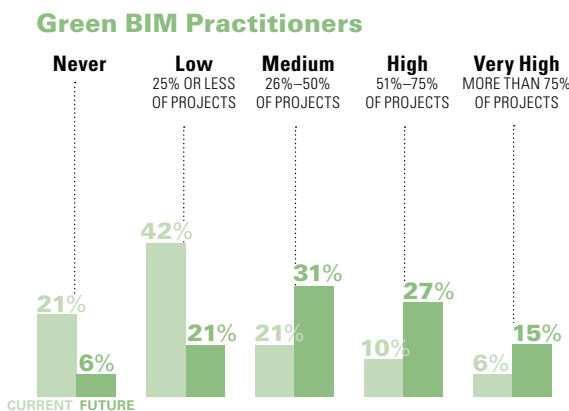
■ Contribution Toward Greener Site:

- Medium: 44%
- High: 31%

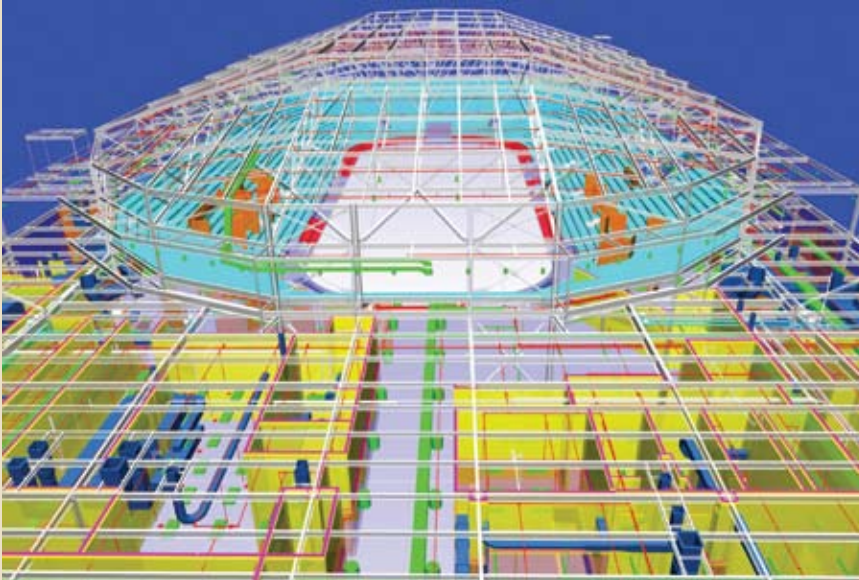
Firms that do not use BIM for green projects, on the other hand, predominantly identify prefabrication as a medium to low contributor to greener buildings and project sites. This differential suggests that greater experience with using BIM for green design and construction leads to higher expectations about the potential it poses for prefabrication. As experience grows, it should help drive industry adoption of BIM models for prefabrication.

Current/Future Use of BIM Model-Driven Prefabrication

Source: McGraw-Hill Construction, 2010



BIM, Lean and Green



© Mortenson Construction

ShoWare Center, Kent, Washington

With a focus on reducing waste, many lean construction methods are inherently sustainable. Because building information modeling has introduced more efficient ways of carrying out common tasks for designers and contractors, BIM has taken a prominent role in supporting lean practices and producing sustainable results.

"The more efficiencies and less waste you use in the process, the more 'green' the project is," says Derek Cunz, vice president and general manager at Mortenson Construction in Minneapolis.

BIM is Critical to Achieve Lean Goals

Mortenson began adopting lean principles in the mid-1990s, such as an improved focus on early planning, improved coordination and ways to prefabricate components. With the evolution of BIM, Cunz says the technology is now a critical tool for achieving those goals today.

"We had this road map, and BIM has weaved its way through a lot of those principles," he says. "We see BIM and lean as intermixed now, and over time we've been able to leverage them better. The tools are more efficient, so we're able to do this on any scale of project as opposed to just the megaprojects where you can afford the investment. The granularity and level of detail is getting better and better. We've also seen an evolution of the model flowing deeper into the field to integrate the work and affect the craftworkers directly. That's where the lean aspect really starts to take hold."

CONTINUED

Integrated Work Plans

Among the ways that BIM has enabled Mortenson to develop new lean practices in the field is through integrated work plans. On the \$55 million 154,400-sq-ft ShoWare Center project in Kent, Wash., the firm created concise, stand-alone documents for craftworkers for each feature of work.

“This takes your typical drawings—like mechanical, electrical, architectural, civil and instruction sheets—and burns them into a single set of instructions for each craftworker for the work he or she is doing,” Cunz adds. “That is really only achievable though BIM.”

Cunz also credits the process for helping reduce errors and rework in the field. With the help of coordination efforts, the project saw a 38% reduction in requests for information compared to similar projects, helping eliminate additional waste. Cunz estimates that the project saved the owner more than \$1.7 million in projected costs.

Preventing Waste

Although the project was designed to achieve LEED Gold certification, Cunz maintains that the building is greener than its rating suggests.

“The more efficiencies and the less waste you use in the process, the more green the project is.”

—Derek Cunz,
vice president and general manager,
Mortenson Construction

“If you’re delivering more precision to the job site, there’s less waste,” he says. “That’s a green story, but it doesn’t get you LEED points. Less waste means less material to recycle. You get points for recycling, but not for the material that you didn’t use and prevented from having to be recycled.”

Prefabrication

Prefabrication and modularization are other emerging lean practices that have gained momentum through the use of BIM. To reduce waste and errors, prefabrication is being used heavily on the two-phase School of Cinematic Art at the University of Southern California project in Los Angeles. The project architect, Dallas-based Urban Design Group (UDG), used prefabrication as much

as possible, says Ray Kahl, managing principal of UDG.

“We had to meet a tight schedule and a tight budget with little room for error, and prefab allows you to achieve those things,” he said.

On the 137,000-sq-ft Phase I, which broke ground in 2006 and completed in 2009, BIM was used extensively, with the team sharing nine different 3D models created in software including Revit, Tekla and AutoCAD.

Working in partnership with the contractor, Hathaway Dinwiddie of San Francisco, the team conceived multiple prefabricated building components, including roof trusses, roof panels, ceilings, plumbing trees, reinforcing and drywall. By using BIM models to help design and fabricate these components, Kahl says the project realized significant waste reduction in both materials and schedule.

Maximizing Impact of Sustainable Design

“If you do sustainable design, you need to incorporate the elements of lean construction,” he adds. “If you’re focused just on collecting LEED points, you’re missing things that have a real impact on what true sustainable design should be.” ■



School of Cinematic Art at the University of Southern California, Los Angeles, California

© Courtesy of View by View

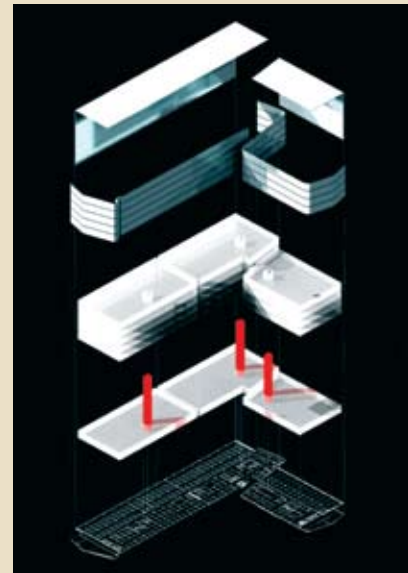
Overcoming the Challenge of BIM on Large Projects while Achieving Energy Efficiency

**U.S. Food and Drug Administration Headquarters Consolidation
Southeast Quadrant**
SILVER SPRING, MARYLAND

GREEN BIM



Southeast Quadrant Laboratory Building



© KlingStubbins in association with RTKL

The Southeast Quadrant, with a laboratory building and two office buildings totalling over one million square feet, is just one element of a larger plan to consolidate all U.S. Food and Drug Administration facilities in the Washington, DC region into one location. Work on the project has been underway since 1996, with one design team, KlingStubbins in association with RTKL, responsible for the overall project.

Decision to Use BIM

Using BIM on one portion of a massive project already underway involved making a major transition. However, as Alberto Cavallero, AIA, LEED AP, design principal at KlingStubbins reveals, by the time they began work on the Southeast Quadrant, KlingStubbins “had committed ourselves to BIM as a practice.” The decision to use BIM was informed by other very large

projects they had recently completed with BIM as a tool.

The Challenge of Using BIM on Very Large Projects

As they worked on these large projects, the design team at KlingStubbins found that they pushed the limits of the software. Nonetheless, Cavallero has no doubt that BIM was the right approach to designing this project: “I honestly do not think the software was designed for something of such colossal size, but it works, and it works very well.”

Because attempting to do the entire project as one model in BIM was impossible on a project of this scale, the work-around devised by the KlingStubbins team was to create multiple models. On a project like this with over one million square feet, Cavallero estimates that as many as 12 to 20 models need to be created within BIM to design the building. He points out that this

creates challenges envisioning the project holistically. “BIM likes to have the whole building in the memory of a single computer, so that the computer can understand holistically what is going on, but the complexity [of a project this size] makes it impossible to do that.”

A critical part of their strategy is to keep the components as simple as possible. He describes how, on another large project, they learned that an element like a 3-D workstation model with a camera can seem like a great addition, but when it is copied a thousand times, it can crash a computer system. “In a small project, that’s a perfectly fine thing to do, but in a very big project, you are going to have to take the additional step of dumbing down elements like that” to deal with the limitations of memory.

KlingStubbins also benefited from having people dedicated to coordinating the model. “For a project of significant scale, we have a digital design coordinator in every

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U.S. Food and Drug Administration Headquarters Consolidation Southeast Quadrant

SILVER SPRING, MD

discipline, every team, and you are always talking through these issues... There is a lot of art and finessing to [working with and coordinating the models], and no one should believe that you can just model everything and take pictures." Having digital design coordinators brings that art and vision to the process of working with the models.

Given the challenges that using BIM for a project this scale presents, Cavallero admits that at times he wonders "why we are putting ourselves through the pain of doing this." He feels that his design team is committed to BIM. "If we were to ask them, 'What if I told you on the next project, you have to go back to plain old 2D [design]?', I think they'd rebel. I think they'd actually go get a job somewhere else."

BIM Informs Good Design for Energy Conservation

The team's commitment to BIM can be attributed, in part, to how the tool allows them to make informed decisions from early in the design process, decisions that impact overall building design but that also translate into creating small details. On this project, Cavallero describes how they modeled nearly the entire building in BIM. "I'm not saying that we had absolutely everything modeled, but we came quite close to it, and it was an exercise in really pushing the limits."

Cavallero explains that they do comparative energy modeling early in the design process, and that modeling informs all stages of the design. For example, he describes how they compare different massing diagrams using a quick energy model to "understand the big-scale energy

consequences of the location, form and orientation of the building, which is great because it really facilitates early decision making."

As the design continues, "those early energy modeling decisions trickle down into the final detailing," according to Cavallero. The information from the early modeling leads "to smart decisions in terms of programming and detailing the building that are so much more immediate when you have architects literally playing with these tools early on, doing a reflected light daylighting analysis or doing a thermal exposure analysis to understand the amount of heat on a surface." For him, the BIM tools speak to how architects work: "Architects are graphics people, so when they can see these things, it gives them that much more immediacy into the design process."

The way in which the early energy modeling contributed to the design of project details can be seen in a comparison of curtain-wall details on the south side of the laboratory building versus the north side. The wall on the south side "has a perforated metal screen over half of the glass controlling daylight into the laboratories" while the north side "has offices facing into a courtyard with a very open, transparent curtain wall." For Cavallero, BIM is "a very important tool to refine the formerly intuitive decisions that architects make."

Improving Energy Design in BIM

As useful as Cavallero finds BIM for energy design, he also sees its limitations. All of the energy modeling in BIM is done using relatively simple, comparative tools early in design. He would like

to use BIM to access the ASHRAE energy modeling done by the engineers to be able to see detailed energy results. "We still have to have an engineer build an entirely independent model, and it's a shame because if those conduits were more robust, we could iterate a lot more and really tune the building to [the model]." He expresses a desire to know "the real results" of building energy use to fully integrate the results into the design process and produce the best building possible. ■

Project Facts and Figures

stats

Owner

U.S. General Services Administration (GSA)

Architect

KlingStubbins
in association with RTKL

Structural and MEP Engineer

KlingStubbins
in association with RTKL

Landscape Architect

Sasaki Associates, Inc.

Civil Engineer

Greenhorne & O'Mara
Consulting Engineers

Project Scope

Laboratory Building, Two Office Buildings, Parking Garage

Size

Laboratory: 429,000 square feet

Office: 723,000 square feet

Parking Garage:

928,500 square feet

Scheduled Start

August 2010

Scheduled Completion

November 2013

Green Certification

LEED Silver (anticipated)

Glossary

Definition of Terms Used

Building Information Model (BIM):

A BIM is a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility and forms a reliable basis for decisions during its lifecycle from inception onward. BIM also refers broadly to the creation and use of digital models and related collaborative processes between companies to leverage the value of the models.

Building Massing Modeling:

Evaluation of the building's three-dimensional form, including its basic shapes and scale. Design choices made in building massing, like building orientation, can impact overall energy use.

Daylighting Analysis:

Simulations conducted during the design process that measure the amount of natural light entering into a building. The analysis allows design teams to gauge the impact of different daylighting approaches on building systems. Typical outputs include: radiation maps, climate-based metrics and glare analysis.

Energy Performance Simulation:

Energy performance simulation programs are software tools used to estimate energy performance and thermal comfort. They are typically used during the design and construction phases of a building, and they are based on basic building characteristics.

Green BIM:

The use of BIM tools to help achieve sustainability and/or improved building performance objectives on a project.

Green Buildings:

A building constructed to LEED or other green building standards, or one that involves numerous green building strategies across several categories, including energy, water and resource efficiency and improved indoor air quality. Projects that only involve a few green building products (e.g., HVAC, waterless urinals) are not included in this definition.

Green Firm:

A firm whose practice primarily involves green projects (more than 75% of its total projects).

Green Retrofit:

Renovation work undertaken on existing buildings that meets LEED or other green building standards or that includes numerous building strategies across four category areas: energy, water and resource efficiency and improved indoor air quality. Projects that only involve energy efficiency improvements or just a few green building products are not included in this definition.

High-Performance Building:

A building that uses a whole building design approach to achieve energy, economic and environmental performance that is substantially better than standard practice.

Integrated Design Process:

Active participation in all stages of design for all disciplines involved in the design, construction and, at times, the operation of the building. An integrated design team usually includes an owner's representative; architect; mechanical, electrical and structural engineer; and construction manager and/or general contractor. It can also include future building occupants, facility managers and maintenance staff, subcontractors for major trades and building product manufacturers.

Definition of Terms Used

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Integrated Project Delivery:

The delivery of a construction project according to a contract that calls for an integrated design process (see page 50) and that clarifies the legal responsibilities and risks born by all members of the project team.

Leadership in Energy and Environmental Design (LEED):

An internationally recognized green building certification system developed by the U.S. Green Building Council, providing third-party verification that a building or community was designed and built using strategies intended to improve performance across the following metrics: energy savings, water efficiency, CO₂ emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts.

Lean Construction:

The Associated General Contractors of America (AGC) defines lean construction as a set of ideas based in the holistic pursuit of continuous improvements aimed at minimizing costs and maximizing value to clients in all dimensions of the built and natural environment: planning, design, construction, activation, operations, maintenance, salvaging and recycling. Lean construction is conceptually based on lean practices in manufacturing. (For more information, see the AGC Lean Construction Forum, <http://agcleanforum.org/about/>.)

Lifecycle Analysis:

A method of determining the environmental impact of a building product by evaluating its entire lifecycle—from material procurement through manufacture, delivery and installation to disposal/recycling.

Net-Zero Energy Building:

A building that uses no more energy than it generates through a combination of energy-efficiency measures and on-site renewable energy generation. The U.S. Department of Energy has been charged with developing marketable, net-zero energy commercial buildings by 2025, as required by federal law set forth in the Energy Independence & Security Act of 2007.

Prefabrication:

The practice of assembling components of a structure in a factory or other manufacturing site and transporting complete assemblies or subassemblies to the construction site where the structure is to be located. Model-driven prefabrication describes the use of the BIM model to enable prefabrication and assembly of building components both off and on the construction site.

Non-Green BIM:

When BIM is not used to help achieve sustainability and/or building performance objectives on a project.

Rainwater Harvesting:

A green strategy that replaces potable water with collected rainwater for landscaping or nonpotable interior uses such as toilet flushing.

Value Engineering:

Analysis conducted late in the design process or during construction aimed at reducing the cost of construction.

Whole Building Design and Performance Simulation:

Whole building design is a process that views the building as an integrated system, rather than a collection of components. An integrated design process assumes that a number of building solutions will be considered and that some degree of analysis will take place to compare strategies and determine which ones are appropriate to achieve the desired performance. Performance simulation of daylighting, energy use, water use and air flow are methods that can be used to conduct this analysis.

Methodology:

Green BIM Study Research

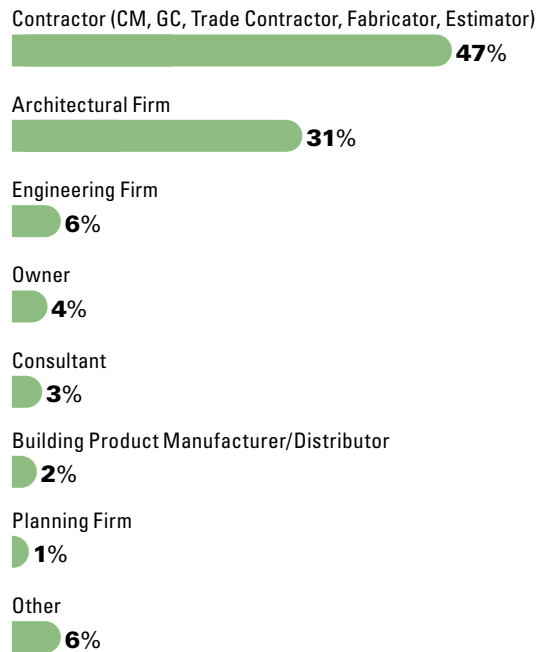
McGraw-Hill Construction conducted the 2010 Green BIM Study to assess the level and scope of use of BIM tools to help achieve sustainability and/or building performance objectives on projects as well as the expected level and scope of use in the future.

The research in this report was conducted through an internet survey of industry professionals between May 24 and June 23, 2010. The survey had 494 complete responses. The “total” category displayed throughout the report includes 182 architects/engineers (37%), 233 contractors (47%) and 79 other industry respondents (16%)—including owners, building product manufacturers, government agencies, various integrated firms and consultants.

The use of a sample to represent a true population is based on the firm foundation of statistics. The sampling size and technique used in this study conform to accepted industry research standards expected to produce results with a high degree of confidence and low margin of error. The total sample size (494) used in this survey benchmarks at a 95% confidence interval with a margin of error of less than 5%. For the architect/engineer category, the confidence interval is 95%, with a margin of error of 7%; and for the contractors category the confidence interval is 95%, with a margin of error of 6%.

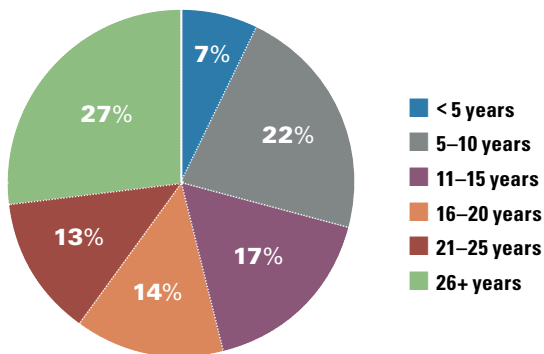
Respondent Firm Type

Source: McGraw-Hill Construction, 2010



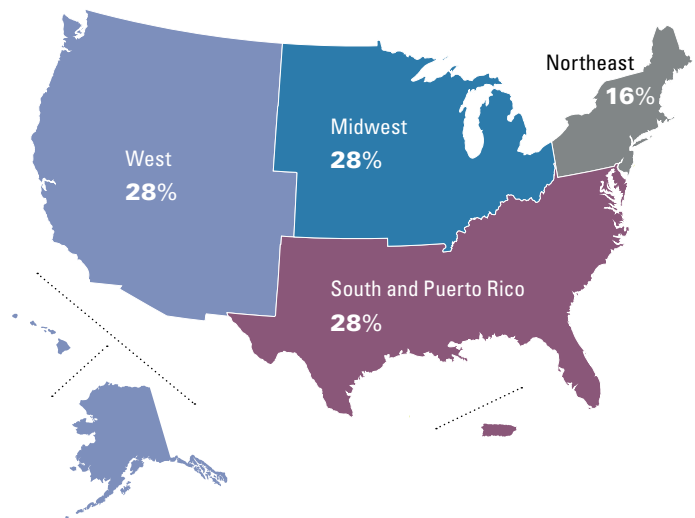
Respondent Tenure in Firm

Source: McGraw-Hill Construction, 2010



Respondent Region

Source: McGraw-Hill Construction, 2010



Resources

Organizations, websites and publications that can help you get smarter about green buildings and building information modeling

McGraw Hill CONSTRUCTION

McGraw Hill Construction

Main Website: construction.com

GreenSource: greensourcemag.com

Research & Analytics: construction.com/market_research

Architectural Record: archrecord.com

Engineering News-Record: enr.com

Sweets: sweets.com

Green Reports:

greensource.construction.com/resources/SmartMarket.asp

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U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE): eere.energy.gov
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U.S. General Services Administration: gsa.gov
Energy Star: energystar.gov
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Construction Owners Association of America: coaa.org
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National Association of Women in Construction: nawic.org
National Electrical Contractors Association: neca.org
National Institute of Building Sciences: nibs.org

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Other Resources

American Society of Heating, Refrigerating and Air-Conditioning Engineers: ashrae.org
Building Green, LLC: buildinggreen.com
Carnegie Mellon University, Center for Building Performance and Diagnostics: arc.cmu.edu/cbpd
Green Building Initiative: thegbi.org
University of California Berkeley, Center for the Built Environment: cbe.berkeley.edu
National Renewable Energy Laboratory: nrel.gov

■ Design and Construction Intelligence

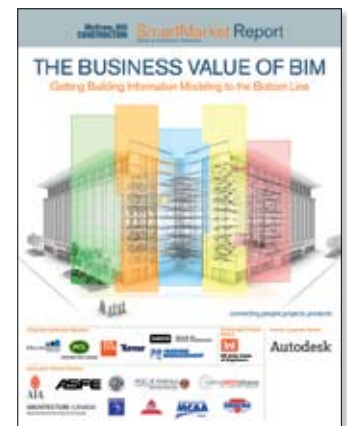
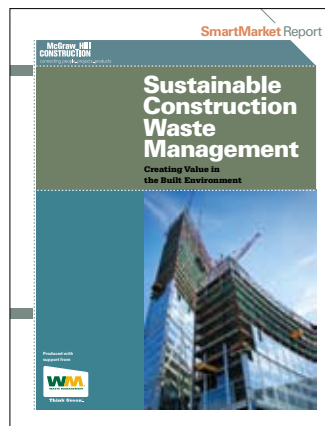
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