SUMMARY REPORT

Survey of local & national design teams

to identify gaps in building design & delivery process

with specific emphasis on Integrated Design

submitted by
Muscoe Martin, AIA
Lecturer

University of Pennsylvania
School of Design

2/29/12

TABLE OF CONTENTS

SUMMARY REPORT
Survey of local & national design teams to identify gaps in building design & delivery process with specific emphasis on Integrated Design.

EXECUTIVE SUMMARY

According to the GPIC SOPO a major reason for the lack of improvement in energy efficiency in buildings is that design and construction practices are not sufficiently integrated. In other words, buildings are designed and delivered by separate professions and construction trades who do not collaborate or coordinate together closely enough, particularly for renovations. To evaluate this claim we researched the literature on the current theories of "integrated design" and conducted a series of interviews with architects, engineers and others involved in commercial retrofits. Our focus was to understand: 1) what does "integrated design" mean to the practitioner and 2) to what extent is "integrated design" actually being practiced?.

WHAT IS INTEGRATED DESIGN?

"Integrated design" is a widely used term, however a literature search and extensive interviews with local and national design firms did not find a concise, commonly accepted definition. However, our research did find five types of strategies that were most frequently mentioned as elements of integrated design:

1. SYSTEMS APPROACH
2. COLLABORATIVE DESIGN PROCESS
3. ADVANCED DESIGN TOOLS
4. MEASURABLE PERFORMANCE GOALS
5. POST-OCCUPANCY VERIFICATION OF PERFORMANCE

These elements differ from industry standards by requiring more upfront analysis and iteration during design, as well as a greater focus on energy performance metrics, both pre- and post-construction.

HOW WIDELY IS INTEGRATED DESIGN USED IN ACTUAL PRACTICE

Our research suggests that that design firms are utilizing some aspects of integrated design practices on some of their projects. Very few, however, are employing a comprehensive integrated process as standard practice - and then only on larger, higher-profile new buildings. Perhaps more relevant to GPIC, almost none of the firms reported employing integrated design practices on existing buildings, except the occasional, larger renovation that involved a complete reconfiguring of the building ("gut rehab").

The anticipation of increased costs was the most common reason mentioned for the inability to adopt a more completely integrated design approach. Many of the professionals told us that clients were unwilling to pay for added initial costs for the additional process and services common to integrated design, such as energy modeling, design charrettes and energy audits. Without incentives or clear evidence that there would be a satisfactory payback, there is little call for integrated design processes that might deliver energy efficiency, especially for renovations.

Our analysis also demonstrated that the one aspect of the theory of Integrated Design that is rarely seen in practice is Performance Verification. Very few firms reported they are consistently tracking the real-life performance of their buildings. Without this tracking of post-occupancy building performance it is difficult to evaluate the impact of integrated design practices, innovative technology and system selections, on actual energy use. We believe this is a major impediment to widespread adoption of integrated design practices.


PROCESS

INTRODUCTION

"A great building...must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable."

– Louis Kahn, Architect

This quote, from renowned Philadelphia architect Lou Kahn, may seem overly poetic for a report focused on energy efficient design, yet it actually describes one of the fundamental barriers to achieving improved performance in buildings. Buildings represent many things to us, some definable, others less so. Architects, engineers, builders, owners, users, investors, janitors, passersby, indeed anyone who encounters a building, all have different ways of evaluating its "performance." Some use quantifiable metrics (how much did it cost?, did I make a profit building it?, how many BTU's does it use?), while others prefer less quantifiable criteria (is it beautiful?, am I comfortable inside?, would I like to work/study/live there?). These varied, disparate perspectives make it difficult to develop a common language of building assessment, even among design and construction professionals. Without consistent, reliable metrics, It should be no surprise that the building industry is unable to deliver consistent, reliable performance.

Recognizing this context, a major premise for GPIC is that this fragmented industry is unable to produce more energy-efficient buildings (EEBs) because the separate professions and trades do not collaborate or coordinate together closely enough. This dis-connected process misses opportunities for a more integrated approach that could first, identify shared performance targets, then develop common strategies to deliver that performance, and, finally, measure that performance in the finished product. Such an approach is not yet widely adopted.

The Case for Integrated Design

The graph shown in Figure 1 illustrates the current context for EEB's. Over the past 50 years the energy efficiency of individual building components, such as lighting, window glass and cooling systems, have improved significantly. Over the same time period, however, the efficiency of all buildings in the U.S. has hardly improved at all.

We believe there are two significant factors for this gap. First is the persistence of existing buildings that have not been retrofitted with the new technologies. In the 10 county GPIC region, for example, 36% of commercial buildings have had no renovations since 1980. More specifically, 58% have had no HVAC renovations, 58% no lighting renovations and 64% no window replacement. In other words, more than half of the existing buildings are not taking advantage of even 20-year-old technologies, much less the dramatically improved energy efficient systems available today.

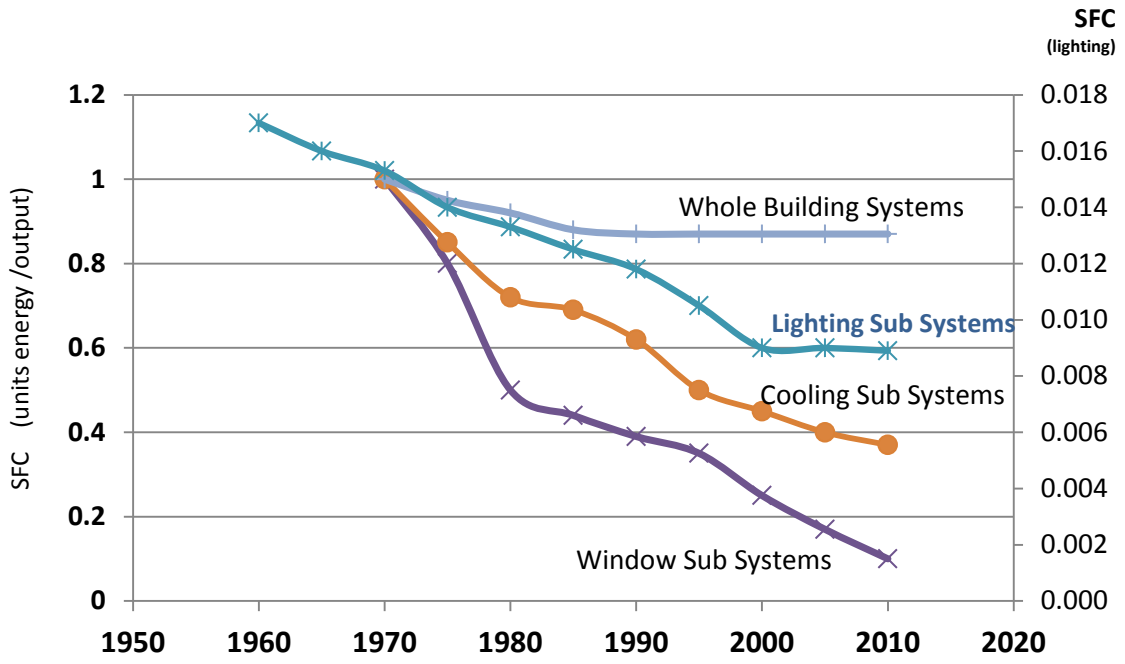


Figure 1: Energy Performance of Building Sub-systems and Whole Buildings

A second and equally important factor suggested by the data illustrated in Figure 1 is that building energy efficiency in new construction has also not improved at the same rate as individual technologies. One possible reason for this are that the new systems are not being deployed widely enough in new buildings. There is some data to support this contention. For example, published reports suggest that "high performance windows" are used in less than 50% of new construction.[1] Other data indicate that 3/4 of commercial buildings, even those built after 1980, do not use the highest efficiency light fixtures available.[2] The Zero Energy Commercial Building Consortium states that "a large number of commercially available technologies that can provide additional, cost-effective energy savings are markedly underutilized.[3]" This all suggests that there is tremendous opportunity for even "state-of-the-shelf" technologies to provide energy efficiency in new construction.

Another reason for the lagging whole-building energy consumption is that, even when the new technologies are deployed in new structures, they are not being deployed effectively. Evidence from the literature shows that if energy efficient components are not used in proper combinations that work together, the whole will not produce an energy efficient building.

Whether the issue is lack of deployment of proven energy efficient technologies or ineffective deployment, this is a DESIGN problem, not a TECHNOLOGY problem. The

components are available and proven, but the industry is not getting them into buildings in a widespread or effective manner.

This inability to effectively integrate the various systems into a complete, high performing building can be at least partially blamed on the fragmentation of the building industry noted above. The designers and installers of the separate building components do not typically work together closely enough to understand how their individual decisions effect the other systems, and ultimately, the total building performance. For example, an architect typically selects the size and type of windows for a building very early in the design process. The impact of these window decisions on energy use is enormous, yet is often not considered until later in the design process when the HVAC engineer is brought in. Even if the engineer recommends changing the windows to save energy, It is often too late.

When an architect does consider energy efficiency early in the design, selecting high-performance windows, for example, the engineer may be reluctant to consider this in the HVAC system selection because they worry that cheaper, less efficient windows will be installed by the builder. Without early collaboration, shared trust or common performance goals, the results are rarely satisfactory.

> "Major strides in reducing energy use will not be achieved unless integrated design becomes a standard practice and not the niche of sustainable building practitioners."
>
> - *Zero Energy Commercial Buildings Consortium, NEXT GENERATION TECHNOLOGIES: Barriers & Industry Recommendations For Commercial Building,s FINAL REPORT - FEBRUARY 2011*

The building industry has begun to recognize this as a problem - but also an opportunity. Many leading professional designers and builders have been modifying their standard practices to involve more intentional collaboration of key participants in the design and construction process. The growth of building performance evaluation systems, like LEED™ and EnergyStar, have helped drive this move to a more comprehensive design approach. Indeed, *Integrated design* and *integrated project delivery* have become popular buzz words in the building industry. A quick scan of current publications and leading practitioners' websites will lead to multiple hits on these terms. It seems that every firm of any size or reputation claims to practice "integrated design. "

RESEARCH GOALS & PROCESS

Given this current context, we set out to answer three questions:

1. Is there a shared definition or understanding of "integrated design?"
2. How widely Is integrated design being practiced in the industry, particularly on commercial renovation and retrofit projects that are the focus of GPIC?
3. If everyone is practicing integration, why aren't we seeing the results in the performance of buildings?

To answer these questions we needed to understand the industry's current practices related to integrated design. We began with a review of published literature and case studies regarding links between low-energy design and integrated practices. Once this was completed, we developed a set of questions for personal interviews with design and construction professionals. We identified a group of local professionals plus a smaller sample of regional and national firms and conducted face-to-face and telephone interviews. Finally, we analyzed the information from the literature review and interviews to develop provisional responses to our three questions.

REVIEW OF GPIC SOPO

Prior to starting our research, our first task was to look inward. We reviewed the GPIC "Statement of Year 1 Program Objectives" (SOPO) to see if there was a common definition of integration within GPIC itself. Not surprisingly, we found that the term "integration" was used frequently in the document. Analyzing these instances (see Figure 2), we characterized the definitions into six general areas:

- integrated design
- systems & technology integration
- integrative tools
- economic integration
- integrating others through communication and education
- integration with the surrounding social and physical context.

With some overlap, these separate categories of integration reflect the focus of the different Year 1 GPIC task groups. In other words, each task is using a slightly different definition of these terms that are at the heart of the work of GPIC. To address this, an internal GPIC workshop was held on October 12, 2011 to bring together representatives from other Tasks to start to develop a shared definition of 'integration' for GPIC.

LITERATURE REVIEW - INTEGRATED DESIGN for BUILDINGS

The focus of our work was specifically on design, yet we kept these other spheres of integration from the SOPO in the back of our thinking as we proceeded into the next phase, which was a review of recent literature and case studies on integrated design, energy efficiency, and building retrofits. As noted above, there have been many recent articles and books on the topic of integrated building design. [see Appendix A for the list of publications].

There is also a growing list of case studies describing integrated design and practices for new construction. These projects are typically high profile buildings for institutions, government or large companies. However, as will be evident throughout this report, there are very few case studies or articles on integrated design for renovations or retrofits.

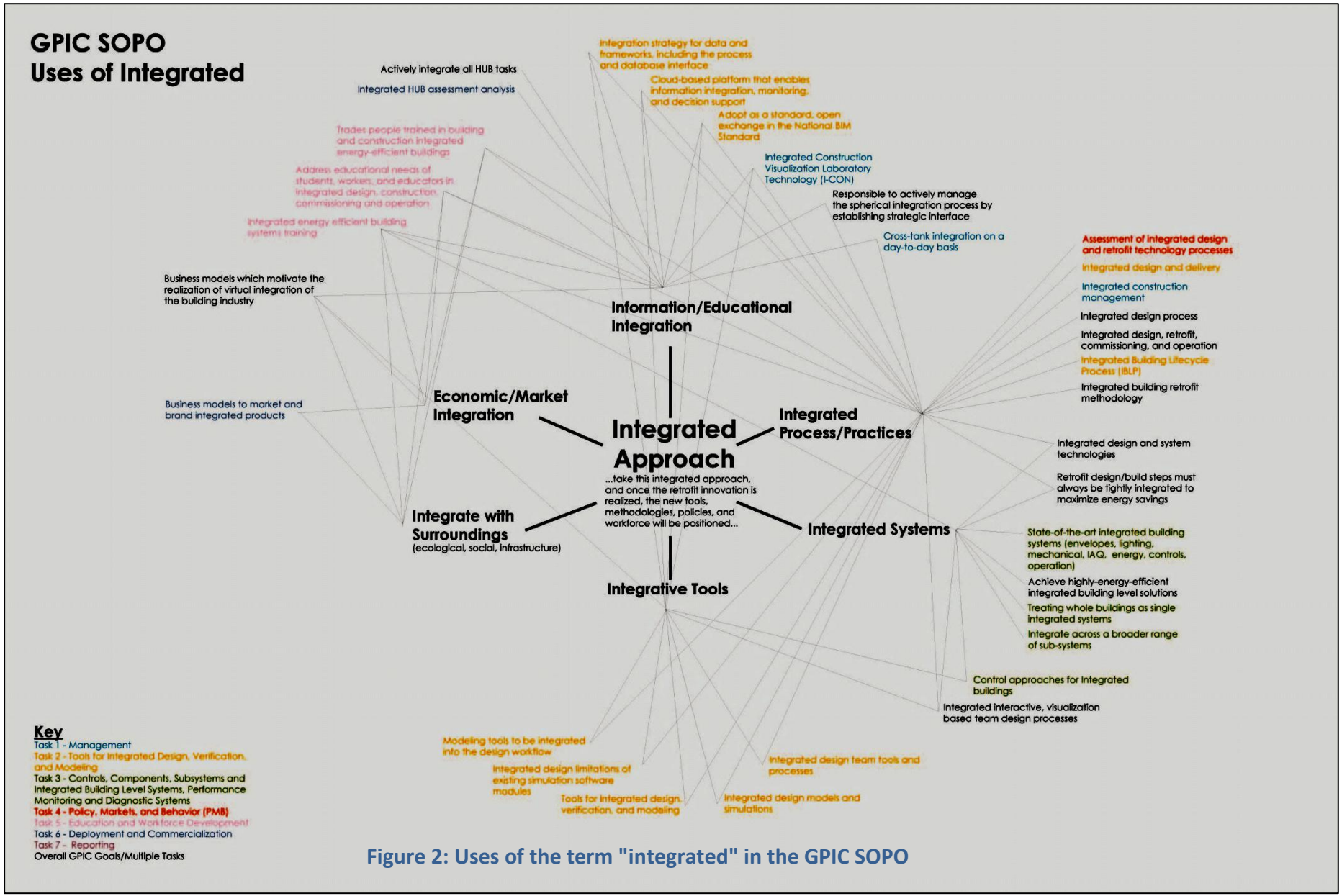


Figure 2: Uses of the term "integrated" in the GPIC SOPO

From this literature review, we compiled a list of definitions of integrated design, , diagrams of the process, and integrated high-performance case studies (see Appendix A.2) Finally, we identified common strategies for achieving integration

INTERVIEWS with LOCAL & NATIONAL PROFESSIONALS

The SOPO search and literature review gave us a general sense of the range of practices that the industry considers to be part of integrated design. The next step was to interview professionals in the design and construction industry to see if they are actually practicing integrated design, what they mean by that term, and how deeply embedded these integrated practices are in their work.

We developed a list of questions tailored to the type of professional to be interviewed (architect, engineer, etc.). See Appendix B.1 for the question lists. Using local contacts and the case studies, we identified potential interviewees. Most were in the GPIC region, with a smaller sample representing national or international firms. Over the summer and fall of 2011, we conducted interviews with 45 individuals from 38 different firms. See Appendix B.2 for list of interviewees.

Typical interview questions

- Do you practice integrated design? If so, how do you define it?
- Does integrated design extend to all of your projects? What about retrofits and renovations?
- How is the integrated process reflected in project contracts?
- Do you hire consultants based on their ability to integrate?
- What are barriers to an integrated process?
- What are the benefits to an integrated process?

Interview Methodology

Using local contacts along with the literature review and case studies, we identified a varied group of local professionals plus a smaller sample of regional and national firms. Over the summer and fall of 2011, we conducted face-to-face and telephone interviews with 45 individuals from 38 different firms. Figure 3.a and 3.b show the types and sizes of firms interviewed. See Appendix B.2 for complete list of interviewees. All of the firms are focused on commercial buildings, and most are involved in both new construction and renovation.

The interviews were conducted using a list of questions tailored to the type of professional (architect, engineer, etc.). The questions were designed to better understand how integrated design is actually being practiced. See Appendix B.1 for complete list of interview questions.

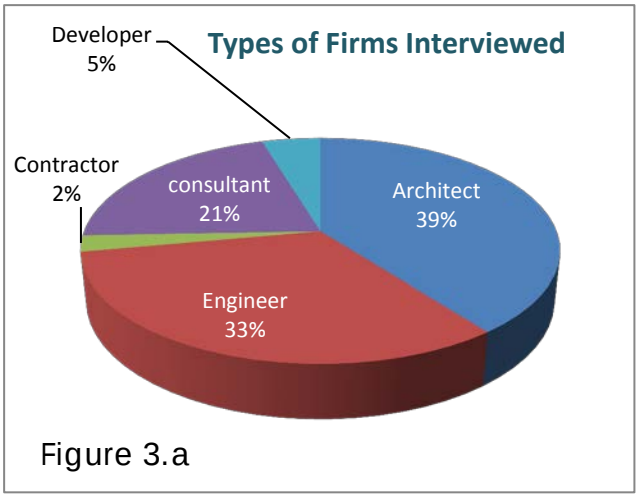


Figure 3.a

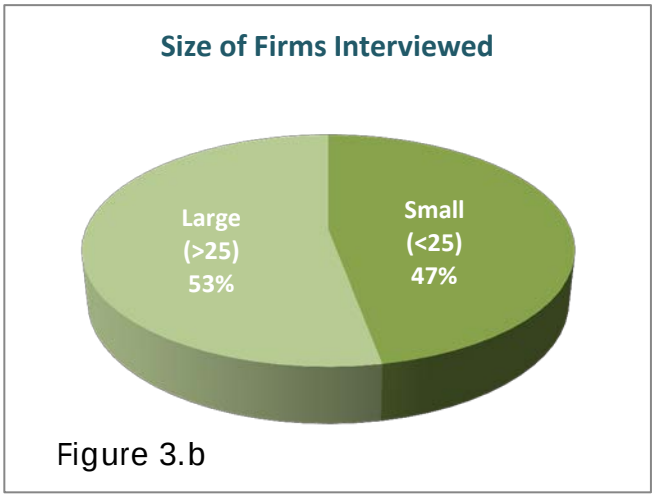


Figure 3.b

Two overriding issues we wanted to explore with each firm were the following:

1. Is there a common definition or understanding of "integrated design?"
2. How widely is integrated design being practiced, particularly for renovation and retrofit projects?

Interview responses were coded in a matrix to allow comparisons and analysis. (See Figure 4) The matrix cross referenced the category and scale of practice, that we termed "Field Of Work," with the Types of Integration identified from the literature review.

Finally, we tabulated the frequency of mention of certain strategies and approaches to identify common themes in the practice of integrated design.

	Interview Matrix					
	Type of Integration					
Field of Work	Process	Systems	Tools	Info/ Education	Economic	Context/ Surroundings
Vision						
Development						
Architecture						
Engineering						
Building						
Consulting						
Technology						
Financial						
Maintenance						
Operation						
Occupancy						

Figure 4: Interview Response Matrix

[1] HIGH-PERFORMANCE WINDOWS: Reduced Heating and Cooling Costs Through Energy-Efficient Technology, Duke University Center on Globalization Governance and Competitiveness, November, 2008.
[2] Commercial Building Energy Consumption Study, 2003, Energy Information Administration
[3] Next Generation Technologies: Barriers & Industry Recommendations For Commercial Buildings, Zero Energy Commercial Buildings Consortium, Feb., 2011.

FINDINGS

DEFINITIONS OF INTEGRATED DESIGN

"I do not like ducts; I do not like pipes. I hate them really thoroughly, but because I hate them so thoroughly, I feel they have to be given their place. If I just hated them and took no care, I think they would invade the building and completely destroy it. – Louis Kahn, Architect

Is there a shared definition or understanding of "integrated design?" Our literature and case study review revealed that, as with the GPIC SOPO, integrated design has a variety of definitions within the industry, but as of yet, no commonly accepted one. In fact, we discovered some general confusion in the terms in use, specifically between two related but different concepts: integrated design and integrated project delivery.

Integrated Project Delivery (IPD) has come to mean an approach to the contractual arrangement between Design Team, Builder and Owner. This is a rapidly evolving approach, but the intention is to develop a collaborative (rather than antagonistic) approach, allocate risk fairly, and encourage a shared commitment to the goals of the project. The sidebar shows the AIA's definition of IPD.

> INTEGRATED PROJECT DELIVERY (IPD)
>
> A project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.
>
> *- American Institute of Architects*

While we found many articles describing innovative contracting approaches, such as Integrated Project Delivery (IPD), we heard of only a handful of projects reporting actual use of these contracting methods. It seems that the legal structure of projects is changing more slowly than design strategies. Most of the interviewees were aware of these contracting methods, but few were using them, nor anticipating that they would be used in the near future.

Integrated Design focuses more on "design," of course, than IPD which is more comprehensive. Integrative design also emphasizes designing to improve building performance (energy and water use, site impacts, human comfort and well-being, etc.). Integrated Design can be generally described as a collaborative approach to design, using a systems view of buildings & technology, to achieve high performance buildings.

We did encounter some confusion about these two, separate, practices, mainly from outside of the industry. These are two distinct and different practices. They are by no means mutually exclusive, but, as currently understood, Integrated Project Delivery

does not always include Integrated Design, nor does Integrated Design always require IPD.

Another terminology distinction that we discovered is between *Integrative* and *Integrated* design. While integrated is the term most often encountered, some practitioners prefer integrative because it implies an ongoing process rather than a completed product. They argue that integration must be ongoing past the design process, into construction and building operations, indeed for the whole life of the structure. While we agree with this statement, we nonetheless follow the more standard usage.

As noted above, we found a number of definitions of Integrated Design both explicitly and implicit in the literature and case studies. Because the notion of integration cuts across professions, the term has not been appropriated by any particularly trade or industry association, although each of the major ones, such as ASHRAE, AIA, and USGBC, have at least attempted a definition. Some of our favorites are shown in the sidebars.

> "..the integrated design process is an approach to building design that seeks to achieve high performance on a wide variety of well-defined environmental and social goals while staying within budgetary and scheduling constraints."
>
> *-British Columbia Green Building Roundtable*

> "In the creation of the built environment, integrated design is the synthesis of climate, use, loads, and systems resulting in a comfortable and productive environment and a building that is more energy-efficient than current best practices."
>
> *-University of Oregon*

> "[Integrated Design] results in a building where all the pieces fit together in such a way that you can't pull one out without affecting everything else."
>
> -Rob Diemer, HVAC Engineer, *InPosse*

THEORY of INTEGRATED DESIGN

Although there is no common definition of integrated design, we did find that the various definitions in the literature shared some common strategies and themes. We have characterized these below as the theory of integrated design. While some definitions focus more on tools, and other more on process

1. SYSTEMS APPROACH: An understanding of building technology that recognizes the critical interactions between architectural design and engineering in effecting building performance.
2. COLLABORATIVE PROCESS: A close collaboration between design, construction, users and building operations team members, involving frequent iterations early in the process; to gain valuable input when it can be effectively incorporated in

the project. A subset of an integrated process involves the use of legal contracts that reflect a shared responsibility and risk for the project (known as Integrated Project Delivery or IPD).

3. MEASURABLE PERFORMANCE GOALS: The use of rating systems (such as LEED or Energy Star) and performance targets for energy consumption to set project goals and guide design decisions.
4. VERIFICATION OF PERFORMANCE: The necessary (and often ignored) companion to Measurable Goals (#3) is post-occupancy verification of the actual building performance, and the use and analysis of that data to influence future design decisions.
5. ADVANCED DESIGN TOOLS: Use of advanced tools such as energy simulation software and Building Information Modeling (BIM) to provide predictive performance feedback during design.

It is worth noting that the written descriptions of integrated design are much more comprehensive than what we heard about from practitioners. The actual practice of design, in general, is much less tidy and organized than the theory, and this is even more the case with the innovative and evolving practice of integrated design. .

PRACTICE of INTEGRATED DESIGN

Of all the firms we contacted for interviews, only a handful declined to participate due to lack of knowledge or interest in integrated design. Of the actual interviewees who were design professionals, 100% told us they practiced integrated design for at least a portion of their projects. It appears that integrated design, at least as a concept, is moving into the mainstream.

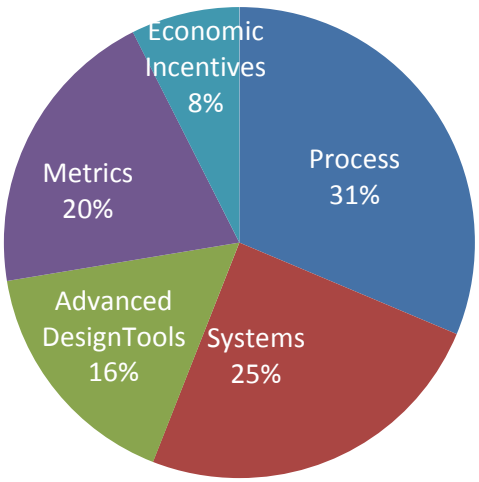


Figure 5: Interview Responses: integrated design practice categories

As with the published literature on the theory of integrated design, there was no shared understanding among the interviewees of the practice of integrated design. The firms were clearly aware of the comprehensive practices described in the literature, and most of the key aspects listed above were mentioned by the interviewed firms. However, the respondents emphasized different aspects in their own practice of integrated design. As seen in Figure 5, the most commonly described were design Process strategies. In fact, the three most often mentioned integrated design tactics were Process related: Charrettes, Coordination and Working with collaborative consultants (Figure 6).

Employment of efficient building systems was the second most commonly described practice. A majority of firms showed a recognition of the interactions between architectural design decisions (building envelope, glass size and type, massing, etc.) and energy systems (lighting, heating, cooling, etc.). .

The use of building performance metrics (energy use, water consumption, etc.) was the next most common category, followed by advanced design tools (BIM, energy modeling) and economic incentives.

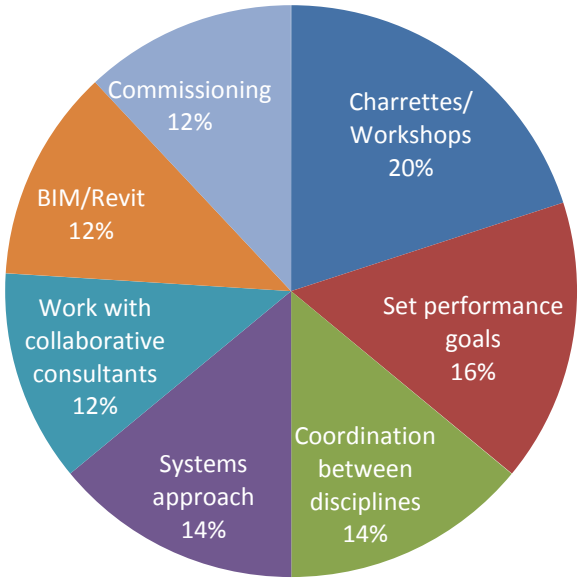


Figure 6: Interview Responses: most commonly mentioned integrated design tactics

CATEGORIES of INTEGRATED DESIGN PRACTICE

The following describes what we learned from the interview regarding each of the integrated design Practice Categories (Figure 5), along with relevant quotations.

COLLABORATIVE PROCESS

Nearly every professional interviewed mentioned some form of of collaborative design process when asked to describe their approach to integrated design. Energy or sustainability workshops or charrettes scheduled early in the design process with all the key design team members were the most common tactic. Participation in these meetings by the builder was preferred when possible.

> "One key of integrated design is being in the same place at the same time…. Despite [new communication & video conferencing] technology, looking at the same piece of paper on a table creates a different atmosphere of collaboration and helps people to integrate more."
>
> - *Philadelphia HVAC Engineer*

> ".. you get all these people who know their [specific] component really well, and as you gain experience working with each other you begin to have that synergy, where people not only know their component really well, but have some understanding of how the other expert is going to work."
>
> - Philadelphia Architect

Many respondents noted that simply holding a "charrette" is not sufficient to ensure integrated design. The ability to collaborate effectively is not universal or consistent among the members of the design professions. Most architects noted that a criteria for selection of design and consultant team members was the ability to be a good collaborator. Some engineers and other consultants commented that not all architects are willing to take input from other parties. "Architects don't want to give up control."

> "Architects need to think more like engineers and engineers need to think more like architects."
>
> - Philadelphia engineer

We heard from both architects and engineers that there is "an inability of architects and engineers to communicate because we understand things differently – we think we're communicating when we're not." This suggests that more widespread training in these concepts might be needed.

SYSTEMS APPROACH

Specific building technologies were mentioned often, including insulation, glazing, building controls, and lighting. Most firms noted the importance of a good understanding of the interrelationships between architectural design and energy systems. Only a few, however, noted that they were able to use this in an integrated design process to really push energy performance down. Those who did describe this process were working on new construction projects with ambitious goals, such as "net zero" or LEED Platinum.

> "…integrated design talks to an end result, which is that you've got a building where all the pieces fit together in such a way that you can't pull one out without affecting everything else. It's almost like a house of cards, you pull out one of the cards and the whole thing falls apart."
>
> - *Philadelphia Mechanical Engineer*

MEASURABLE GOALS

The majority of interviewees were familiar with the use of performance metrics, specifically energy use targets. Energy costs, EnergyStar ratings and energy use intensity (EUI) were all mentioned as potential measures. A few firms noted they always begin projects by setting clear performance targets with clients at the very beginning. Two A/E firms both noted they frequently identify potential energy targets while they are still competing for the design commission. Surprisingly, however, the majority of firms are not typically setting specific energy performance goals other than a LEED rating

VERIFICATION OF PERFORMANCE

The Theory of integrated design requires that real life building performance be measured. This data can then be compared to both the predicted performance as well as provide feedback on the design process, design decisions, and actual operational parameters. This is necessary for the professionals involved to adjust or revise the process, decisions and operations for subsequent projects. Without this feedback, it is almost impossible to determine if integrated design strategies, energy efficient technologies or operational practices are delivering energy efficiency "on the ground."

> "Many of our clients are reluctant to share their energy use data with us, even when they have the information themselves."
>
> - *Mechanical Engineer*

This is one area where our results show a serious gap between Theory and Practice of integrated design. Only a handful of firms are able to find out the actual performance of their built projects, post –construction. Many noted that their clients are reluctant to share this data – "[we} only hear about it when there's a problem." Even those whose practice is focused on green and energy efficient design are "only about 50/50 with getting real time feedback. Its hard to demand feedback."

ADVANCE DESIGN TOOLS

The use of computerized design software, such as energy modeling and BIM, is often perceived to be a critical part of integrated design. Indeed, in the literature, these tools area described frequently. Our interviews suggest that, although most firms make reference to these software tools as part of an integrated process, they are not yet used widely in practice, and then only by the bigger firms, and on large, high profile projects. Many professionals who have been successful at employing integrated design, and are delivering energy efficient projects, have done so with limited use of these expensive and not yet widely adopted tools.

BIM, in particular, appears to be still in its early stages of adoption across all disciplines and enterprises in the design and construction industry. Only a few architecture firms reported widespread use of BIM and even fewer engineering firms. Energy simulation software appears to have a larger penetration in the design world, based on our findings. Some younger designers told us they "dreamed" of a close integration of BIM and energy simulation software, but this dream does not yet appear to be a reality.

HOW DEEP DOES IT GO?

If the majority of design firms are practicing integrated design, why aren't we achieving better energy performance in our buildings? This question remains elusive based on our interviews. It is difficult to really evaluate the penetration of integrated design into the practice and culture of the firms we interviewed, based solely on the interviews we conducted. However, our sense is that, for most firms, integrated design is currently only practiced on a select number of projects. These seem to be the projects where the client has ambitious environmental performance goals, or is at least informed enough to ask for energy use targets.

We also identified a clear distinction between the comprehensive approach described in the integrated design literature ("Theory") and the more limited emphasis on selected aspects of integrated design found in actual practice. Even those professionals who had a thorough understanding of what is required to achieve a fully integrated design, noted that they were "only satisfied with a small percentage of

projects." Others reported success with integrated design "to a certain extent," focusing on selected systems, but not the whole building.

One interviewee, whose organization provides both training as well as consulting to design firms, noted that many professionals they encounter are "comfortable with the jargon but not able to actually implement [integrated design]." We take a somewhat less cynical view and suggest that we are at the early stages of a transition in design and construction practices – and that will take time, and education.

BARRIERS to INTEGRATED DESIGN

Interviewees describe a number of barriers to employing fully integrated design practices on more projects. The most common reason mentioned was the perception of additional time required to fully implement these strategies during design and the associated design costs. While the literature suggests that there are significant benefits of the full approach for both project performance and more coordinated design documents, there does not appear to be sufficient proof of this reflected in actual practice. Most interviewees mentioned the resistance of clients to added fees for integrated design. This was particularly true with smaller renovation and retrofit projects, where the total project fees could not support the added time and costs of the comprehensive integrated design process.

Many noted the time pressure of projects that frequently leads to following the same process that "worked" last time. Integrated design does require a different approach, that must be managed deliberately. It can take more time, particularly if the team does not have previous experience.

Another barrier noted was the "perception from owners [who] think will get better prices if they shop [design] services separately," instead of hiring an integrated design team. We also heard that the practice of bringing the HVAC and lighting engineer on after the building has essentially been designed, is still commonplace. This misses the potential for their early input on the design, when it can have significant impact on energy use. The benefits of integrated design have clearly not yet been communicated convincingly in the industry.

SUMMARY OF FINDINGS

Based on our interviews of design and construction professionals, the majority are aware of the principles of integrated design and its potential for delivering improved building performance. We found that <u>most</u> firms are utilizing <u>some</u> aspects of integrated design practices on <u>some</u> of their projects. Very few, however, are employing as standard practice the comprehensive process described in the Theory of integrated design. Event those firms who are adopting integrated design into their typical approach are only able to employ it on larger, higher-profile, new buildings. Almost

none of the firms represented were employing integrated design practices on existing buildings, except the occasional, larger renovation that involved a complete reconfiguring of the building ("gut rehab").

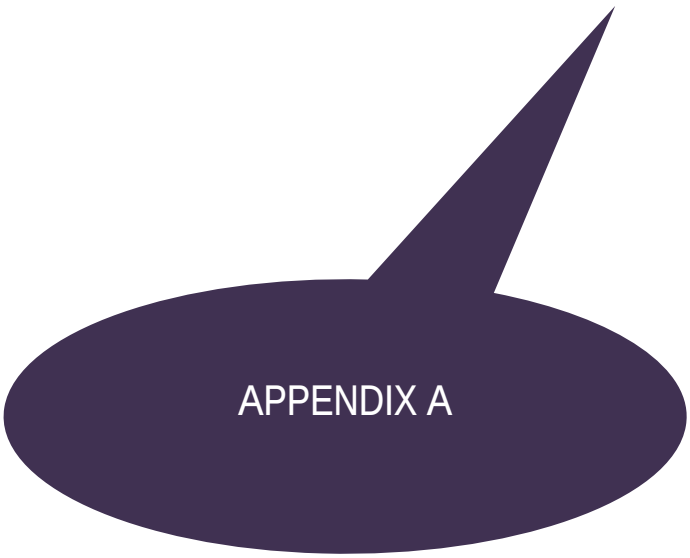
Increased design time and costs were the most common reason mentioned for the inability to adopt the more complete integrated design approach. Many of the professionals reported that clients were unwilling to pay for added early design activities, such as energy modeling, design charrettes and energy audits, without incentives or clear evidence that there would be a satisfactory payback. This was the case even for new construction, but particularly for renovations.

For building renovations, the concern for added costs of a more comprehensive integrated design approach is compounded because these projects typically have smaller scopes of work and related design fees. This suggests that one potential role for GPIC would be to develop shortcuts or streamlined design approaches that incorporate integrated strategies for standard building types. If such tools could be used by design teams without requiring added costs and resources, there would be a greater chance of actual implementation of integrated design on renovation projects.

Our analysis also demonstrated that the one aspect of Integrated Design that is rarely seen in standard practice is Verification of Performance. Very few firms reported they are consistently tracking the performance of their buildings post occupancy. Without this tracking of post-occupancy building performance it is nearly impossible to evaluate the impact of process, design and technological decisions on actual energy use.

In many cases, it was reported that clients and building owners don't have the meters to measure energy use in any meaningful way. Even when they do, many are reluctant to share this data with their professional design teams. However, it is also apparent that the majority of design professionals do not make it a habit to ask for this data. Perhaps they are not really sure they want to know, due to liability issues or potential embarrassment.

Whatever the reasons for the lack of actual performance tracking, we suggest that this may be strongly linked to the perception of added cost to a fully integrated design process. Without this feedback, it is impossible to demonstrate that an integrated design approach is delivering the performance it claims. Professionals don't have the data to show clients that there is value in investing in up-front design services or other integrated approaches, without this feedback. We believe this is a major impediment to widespread adoption of integrated practices.


APPENDIX A

APPENDIX A.1 LITERATURE REVIEW

Integrated Design Publications

Articles	Renovation?	www.wbdg.org/design/engage_process.php
	Betterbricks.com—Integrated design process	www.Betterbricks.com
	Buildinggreen.com—Articles related to integrated design process	www.Buildinggreen.com
	U.S. Department of Energy, Building Technologies Program, Building Toolbox, Integrated Building Design for Energy Efficiency	www.eere.energy.gov/buildings/info/design/integratedbuilding/
	Green Federal Facilities, Section 4.1 Integrated Building Design, by U.S. Department of Energy, 2001	by U.S. Department of Energy, 2001
	"Integrated Building Design," by Ira Krepchin. E Source, ER-00-15, Sept. 2000	by Ira Krepchin. E Source, ER-00-15, Sept. 2000
	Integrated Building Design for Energy Efficiency, by U.S. Department of Energy Building Technologies Program	U.S. Department of Energy Building Technologies Program
	"Strategic Issues Paper: Energy-Efficient Buildings: Institutional Barriers and Opportunities,"	by Amory Lovins. E Source,
	A Handbook for Planning and Conducting Charrettes for High-Performance Projects,	by Gail Lindsey, Joel Ann Todd, and Sheila J. Hayter, National Renewable Energy Laboratory
	Integrated Project Delivery: A Guide. The American Institute of Architects, 2007: www.aia.org/ipdg	www.aia.org/ipdg
	U.S. Department of Energy: www.eere.energy.gov/buildings/info/design/integratedbuilding/passive.html	www.eere.energy.gov/buildings/info/design/integratedbuilding/passive.html
	The U.S. General Services Administration (GSA) agrees and concludes in The Integrated Workplace	GSA
	Whole Building Design Guide, Resource Page, Energy Analysis Tools, Richard Paradis, Steven Winter Associates	: www.wbdg.org/design/energyanalysis.php?r=minimize_consumption
	Whole Building Design Guide, Assure Appropriate Product/Systems Integration, WBDG Functional/Operational Committee:	www.wbdg.org/design/ensure_integration.php
	Dynamic, Integrated Façade Systems for Energy Efficiency and Comfort,	Stephen Selkowitz and Eleanor Lee, Lawrence Berkeley National Laboratory, Journal of Building Enclosure Design, Summer 2006: www.nibs.org/jbed.html
	Guidelines for Creating High-Performance Green Buildings, Commonwealth of Pennsylvania, 1999	
	Ensure Appropriate Product/Systems Integration, Whole-Building Design Guide/Design Guidance/Functional-Operational, on the WBDG Web site:	www.wbdg.org/design/ensure_integration.php.
	Whole Building Design Guide, Building Envelope Design Guide, Fenestration Systems,	www.wbdg.org/design/env_fenestration.php
	Whole Building Design Guide, Resource Pages, Windows and Glazing,	Gregg D. Ander, FAIA, Southern California Edison: www.wbdg.org/design/windows.php?r=env_fenestration-i
	Whole Building Design Guide, Building Envelope Design Guide, Fenestration Systems, Windows, Nik Vigener, PE, and Mark A.	
	Brown, Simpson Gumpertz & Heger Inc.:	www.wbdg.org/design/env_fenestration_win.php

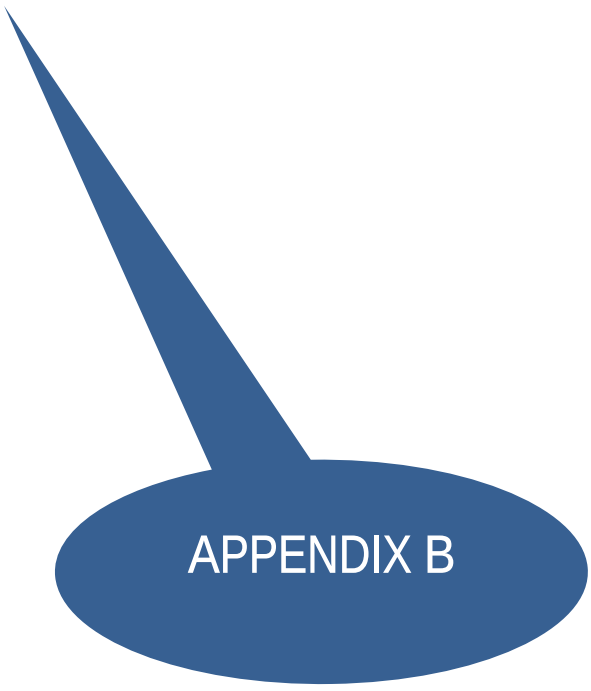
	U.S. Department of Energy, Building Technologies Program, Building Toolbox, Building Envelope, Integrated Design for Building Efficiency, Building Envelope	: www.eere.energy.gov/ buildings/info/design/integratedbuilding/buildingenvelope.html
	Integrated Design Meets the Real World (from Environmental Building News) Allyson Wendt and Nadav Malin	http://www.buildinggreen.com/auth/article.cfm/2010/5/1/Integrated-Desi...
	Roadmap to the Integrated Design Process - British Columbia Green Roundtable	http://www.buildinggreen.com/auth/article.cfm/2010/5/1/Integrated-Desi...
	Integrated Project Delivery: An Interview with Jonathan Cohen, FAIA, LEED AP	http://www.green-buildings.com/content/781469-integrated-project-delivery-interview-jon...
	Achieving High-Performance Federal Facilities: Strategies and Approaches for Transformational Change	http://www.nap.edu/catalog/13140.html
Websites	Better Bricks	www.Betterbricks.com
	Whole Building Design Guide	www.wbdg.org
	New Buildings Institute	http://www.newbuildings.org/
	ASHRAE	http://www.ashrae.org/
	Deep Retrofits	http://www.retrofitdepot.org/
	RMI	http://www.rmi.org/
	AIA	www.aia.org/ipdg
	High Performing Buildings journal	http://www.hpbmagazine.org/
Books	The Integrative Design Guide to Green Buildings - 7group and Bill Reed - John Wiley & Sons, Inc. - Hoboken, New Jersey - 2009	
	Integrated Life Cycle Design of Structures - Asko Sarja - Spon Press - London - 2002	Penn Fine Arts TH 845 S35 2002
	Building Envelopes An Integrated Approach - Jenny Lovell - Princeton Architectural Press - New York - 2010	Penn Fine Arts TH 2235 L68 2010
	Integrated Strategies in Architecture - Joan Zunde and Hocine Bougdah - Taylor and Francis - New York, New York - 2006	Borrow Direct - Dartmouth
	The Handbook of Sustainable Design and Engineering: An Integrated Approach to Energy, Health, and Operational Performance - Dejan Mumovic and Mat Santamouris - EarthScan - London - 2009	Penn Fine Arts* TH 880 H358 2009
	Integrated Practice in Architecture: Mastering Design-Build, Fast-Track, and Building Information Modeling - George Elvin - John Wiley & Sons, Inc. - Hoboken, New Jersey - 2007	Borrow Direct - Princeton
	Fundamentals of Integrated Design for Sustainable Building - Marian Keller and Bill Burke - John Wiley & Sons, Inc. - Hoboken, New Jersey - 2009	Borrow Direct - Dartmouth
	Green Building Through Integrated Design - Jerry Yudelson, PE, MS, MBA, LEED AP - The McGraw Hill Companies, Inc. - New York, New York - 2009	Penn Fine Arts* TH 880 Y635 2009
	Integrated Buildings: The Systems Basis of Architecture - Leonard R. Bachman - John Wiley & Son, Inc. - Hoboken, New Jersey - 2003	Penn Fine Arts NA 2543 T43 B33 2003

	Integrated Design in Contemporary Architecture - Kiel Moe - Princeton Architectural Press - New York, New York - 2008	Borrow Direct - Cornell
	Environmental Design of Urban Buildings: An Integrated Approach - Mat Santamouris - EarthScan - London - 2006	Penn Fine Arts* TH 880 E54 2006
	Integrated Design - GSA/Morphosis/Arup - San Francisco Federal Building - School of Architecture and Planning, University of Buffalo, Buffalo, NY 2008	Interlibrary Loan - Syracuse
Thesis		
	Integrated Design: a generative multi-performative design approach	Fasoulaki, Eleftheria (MIT)

APPENDIX A.2 **CASE STUDIES**

Project Name	Renovation?	Location	Architect	Resources
NREL Research Support Facility				www.nrel.gov/news/rsfnews/features.html
Philip Merrill Environmental Center		Annapolis, MD	SmithGroup, J.H. Heerwagen	human_factors_cbf.pdf
IRS		Kansas City, MO	BNIM	Achieving High Perf Rederal Facilities.pdf
Band Shell		Charleston, SC	BNIM	Achieving High Perf Rederal Facilities.pdf
Re-development Plan		N. Charleston, SC	BNIM	Achieving High Perf Rederal Facilities.pdf
Greensburg Redevelopment		Greensburg, KS	BNIM	Achieving High Perf Rederal Facilities.pdf
Omega Institute		Rhinebeck, NY	BNIM	Achieving High Perf Rederal Facilities.pdf
Odum School of Ecology		U.Georgia, Athens	BNIM	Achieving High Perf Rederal Facilities.pdf
Fort Carson		Colorado Springs, CO	Christopher Juniper	Achieving High Perf Rederal Facilities.pdf
Arlington, VA		Arlington, VA	Garforth Internatl	Achieving High Perf Rederal Facilities.pdf
City of Copenhagen		Copenhagen		Achieving High Perf Rederal Facilities.pdf
City of Guelph		Ontario, Canada		Achieving High Perf Rederal Facilities.pdf
CIRS		Vancouver	Perkins + Will	
Clearview Elemenary School		Hanover, PA	L. Robert Kimball & Assoc.	http://eere.buildinggreen.com/learnmore.cfm?ProjectID=100
Cusano Environmental Education Center		Philadelphia, Pa	SMP Architects (Muscoe)	
AutoDesk AEC Headquarters	X	Waltham, MA	Kling Stubbins	LEED Platinum CI + IPD + BIM
Inland Steel Renovation	X	Chicago, IL	SOM	MIPIM/Architectural Review • MIPIM Future Project Award: Commercial
Christman Company	X	Landsing, MI	SmithGroup	First Double LEED Platinum CS + CI
Empire State Building	X	NYC	Rocky Mountain Institute	
Springs Reserve		Las Vegas, NV	Lucchesi Calati Architects	
MO Dept of Nat Res - Lewis and Clark		Jefferson City, MO	BNIM	
Chicago Botanic Gardens		Chicago, IL		
The Willow School		Gladstone, NJ		
Phipps		Pittsburg, PA		* RFP called for integrative design
Sutter Health				
Alliance Center	X	Denver, CO	Shears Adkins Arch + RMI	
NAVFAC Building 33 (Naval Facilities Engineering Command)	X	Washington, DC	Ewing Cole	
Alberici Corperate Headquarters	X	Overland, MO	Mackey Mitchell Associates	
Comcast Center		Philadelphia, Pa	Robert A.M. Stern	LEED
Independence Pointe Renovation	X	Greenville, SC		Renovation to reduce energy by 40% and water by 50%, LEED- EB silver
Johnson Diversity Distribution		Sturtevant, WI		Largest Green distribution center in US - LEED gold
One Crescent Drive (Navy Yard)		Philadelphia, Pa	Robert A.M. Stern	LEED Platinum
8501 East Raintree Drive		Scottsdale, AZ		LEED Gold
PPL Plaza		Allentown, PA	Robert A.M. Stern	LEED Gold, Top 10 Green Projects 2004 ** collaboration**
Dept. of Devense		Milwaukee, WI		LEED certified
PHH Building		Jacksonville, FL		LEED certified
Stabler Center		Bethlehem, PA		LEED silver shell
Lovejoy Building (OPSIS Offices)	X	Portland, OR	OPSIS Architecture	Integrated design and energy efficient strategies
Crown Hall Renovation (IIT)	X	Chicago, IL	Krueck & Sexton Architects	Climate/Systems analysis, passive strategies

Project Name	Renovation?	Location	Architect	Resources
	X			
Lavin-Bernick Center for University Life		New Orleans, LA	VJAA with James Carpenter Design Associ	Layered, louvered intermediary skin- allow light and air inside, energy eff.
Univ. of AZ College of Arch. And landscape arch	X	Tucson, AZ	Jones Studio	Exterior vertical circulation, roof PV, solar hot water, wind turbine, veg. roof
Sidwell Friends School (Reno and add)	X	Washington, DC	Kieran Timberlake Assoc	PV, vegitated roof, vertical wood cladding system
Pittsburgh Glass Center	X	Pittsburg, PA	Davis Gardner Gannon Pope	reuse to minimize embodied energy
Harvard Blackstone Office historic reno	X	Cambridge, MA	Bruner/Cott & Assoc.	LEED Platinum at no additional cost
Center for Health and Healing				
Manitoba Hydro Headquarters		Winnipeg		
Yale Univ. Sculpture Building and Gallery		New Haven, CT	Kieran Timberlake Assoc	
Biodesign Instutute - ASU		Tempe, AZ	Gould Evans and Lord Aeck Sargent	


APPENDIX B

APPENDIX B.1 INTERVIEW QUESTIONS

ARCHITECTURE FIRMS

Opening Questions:

Briefly describe your profession and any specialization.

Process Questions:

Do you practice integrated design? If so, how do you define integrated design?

In the context of a typical commercial building project, how do you put integrated design into practice?

To what extent are you able to adapt these processes to retrofits?

How do you interact with other members of the design and building team?

Do you choose consultants based on their ability to integrate?

How do you communicate and share information within your office? With other team members? With the client?

Do you use integrative software or tools? What tools would be beneficial to the integrated process?

When does the integration begin? Who is involved?

How and when do you set performance goals? What is used as a baseline? Do you track the performance of your projects?

Do you look for synergies between building systems? Which have been effective?

Do you integrate with your surrounding urban fabric? Infrastructure? Community? Ecology?

How is the integrated process reflected in design contracts? Construction contracts?

How has your integrated process changed over time?

Design Questions:

Does integration in the design process impact architectural concepts or design? If so, how?

Benefits/Drawbacks:

Why do you practice integrated design?

What are barriers to an integrated process?

How does integrated design affect the performance of buildings, especially energy efficiency?

How does integration in your work affect the economy of the project? Of the greater market?

Does integrated design extend to all of your projects? Are your retrofits integrated?

Broad Closing Questions:

In your experience, what are the keys to an integrated process?

Which projects have you found to be good examples of successful integrated design, especially retrofits?

How are these projects performing?

Collect the following if available:

RFPs, RFQs, Contractual Organizations, Internal workflow diagrams, Meeting minutes, Case Studies, etc.

INTERVIEW QUESTIONS – ENGINEERING FIRMS

Opening Questions:

Please describe your profession and any specialization.

What is your role in a project?

Process Questions:

Do you practice integrated design? If so, how do you define integrated design?

In the context of a typical commercial building project, how do you put integrated design into practice?

To what extent are you able to adapt these processes to retrofits? How?

Do you look for synergies between building systems? Which have been effective?

Do you use integrative software or tools? What tools would be beneficial to the integrated process?

How do you interact with other members of the design and building team?

Do you choose consultants based on their ability to integrate?

How do you communicate and share information within your office? With other team members? With the client?

When does the integration begin? Who is involved?

How and when do you set performance goals? What is used as a baseline? Do you track the performance of your projects?

Do you integrate with your surrounding urban fabric? Infrastructure? Community? Ecology?

How is the integrated process reflected in design contracts? Construction contracts?

How has your integrated process changed over time?

Benefits/Drawbacks:

Why do you practice integrated design?

What are barriers to an integrated process?

What indicators have you seen that integration is effective?

How does integrated design affect the performance of buildings, especially energy efficiency?

How does integration in your work affect the economy of the project? Of the greater market?

Broad Closing Questions:

In your experience, what are the keys to an integrated process?

Which projects have you found to be good examples of successful integrated design, especially retrofits?

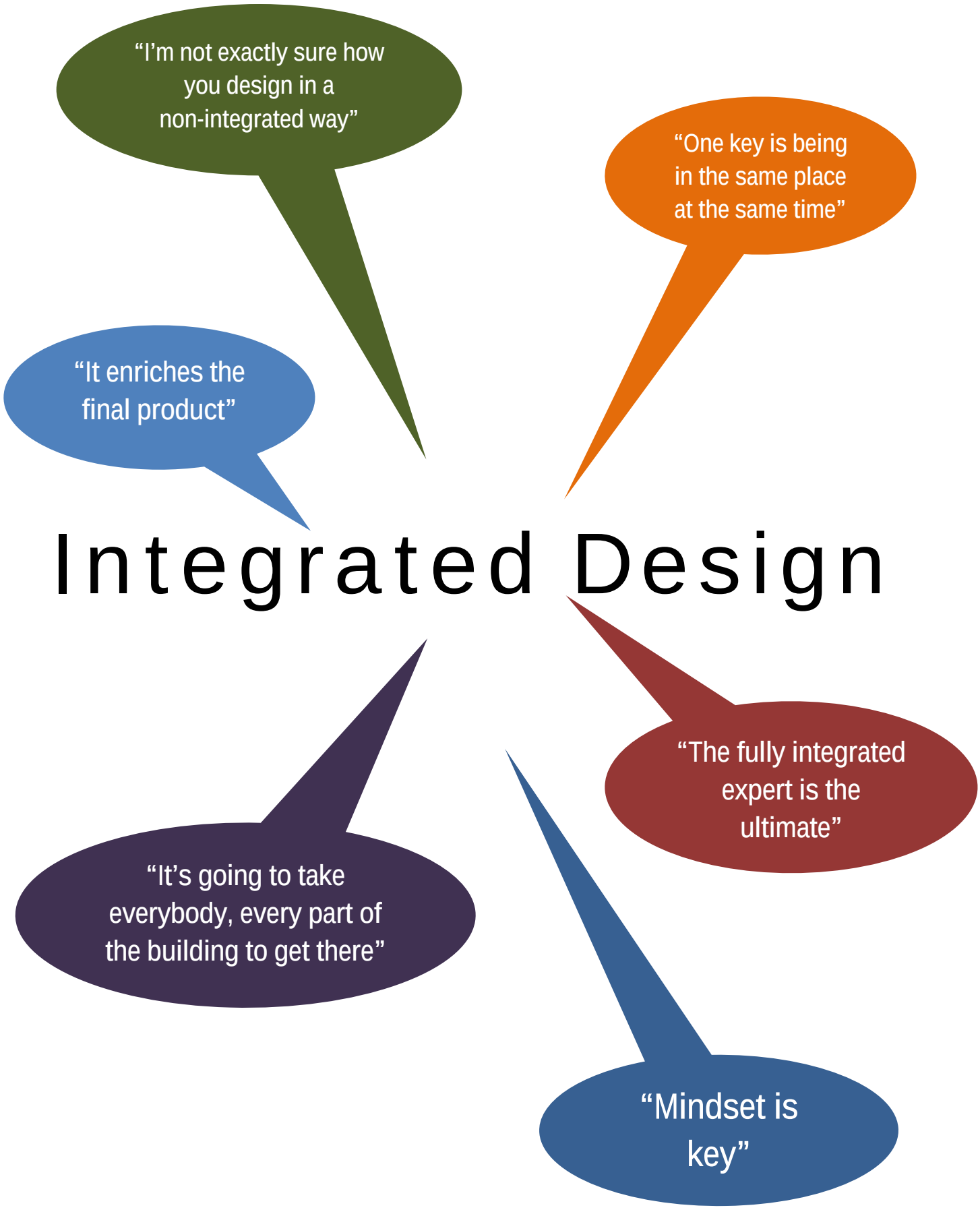
How are these projects performing?

Collect the following if available:

RFPs, RFQs, Contractual Organizations, Internal workflow diagrams, Meeting minutes, Case Studies, etc.

APPENDIX B.2 **LIST OF INTERVIEWEES**

Contact	Company	Specialty
Brian Cohen James Bowes Marla Thalheimer	Liberty Propterty Trust	Real Estate, Development, Leasing
Barbra Batshalom	Green Roundtable Boston	Sustainable Perf. Institute
Todd Woodward	SMP Architects	Architects
Brad Randall	Bruce Brooks	Enginners (M, E, Life Saftey)
Mike Schade	Atkin Olshin Schade	Architects
Jason Kliwinski	Spiezle Group	Architects, Planning
Brian Phillips	Interface Studio Architects	Architects
Jason Fierko Stephen Gastright Mary Alcaraz	Ewing Cole	Architects, Engineers, Planning, Interiors, Lighting, Sustainability
Rob Diemer Shannon Kaplan	In Posse	Environmental Consulting,
Steve Gendler	Grubb and Ellis	Real Estate, Development
Philip Scott	KSK	Architects, Planning, Historic Pres.
Howard Alderson	Alderson Engineering	Engineers
Dan Nall	WSP	Engineers
Sandy Wiggins	Consilience LLC	Environmental Consultant
Rus Perry Greg Mella	Smith Group	Architects, Planners, Engineers
Simon Tickell Jonathan Friedan	Ballinger	Architects, Engineers, Planning, Interiors
Kelly Vresilovic	Bohlin Cywinski Jackson	Architects, Planning, Interiors
Chuck Kensky	Bala Consulting	Engineers
Kevin Keenan	Tozour Energy Services	Energy Services (engineer)
Jonathan Weiss	Kling Stubbins	Architects/Engineers
Chris Schaffner	The Green Engineer	Engineers
Chris Macneal	Kieran Timberlake	Architects
Lauren Yarmuth	YR&G Sustainability	Environmental Consultant
Scott Erdy Dave McHenry	Erdy McHenry	Architects
Tony DiLeonardo Chris Arnold	WFW Energy	Engineers
Dick Winston Morrie Zimmerman	BWA Architects	Architects
Paul Stoller	Atelier Ten	Environmental Consulting, Lighting, Designers
Phil Burkett	Meyer Design	Architects, Interiors
Victor Olgyay Josh Hathaway Cara Carmichael	RMI	Sustainable Research and Consulting
Carl Galioto Jim Berge	HOK	Architects
Terry Jacobs	Jacobs Wyper	Architects, Interior Design, Historic Pres., Sustainability
Makella Craelius	M2 Architecture	Architect
Scott Kelly	Re:Vision Architecture	Architects, Consultants
Mitchell Swann	MDC Systems	Consulting Engineers


"I'm not exactly sure how you design in a non-integrated way"
"One key is being in the same place at the same time"
"It enriches the final product"
Integrated Design
"The fully integrated expert is the ultimate"
"It's going to take everybody, every part of the building to get there"
"Mindset is key"