REALIZING NEXT-GENERATION GREEN

PROJECT DELIVERY AND COST MANAGEMENT STRATEGIES FOR HIGH-PERFORMANCE BUILDINGS

THE AMERICAN INSTITUTE OF ARCHITECTS

INTEGRAL GROUP

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EXECUTIVE SUMMARY

GOALS AND SCOPE

This report seeks to better understand successful project delivery and cost management strategies for high-performance buildings through a series of case studies and a literature review. Two primary questions drove the research:

1. To what extent is Integrated Project Delivery [IPD] implemented in high-performance building projects, and why aren't teams using it in its truest form?
2. What integration strategies are most common and effective in high-performance projects?

We chose four projects on the basis of energy and water performance, including a net zero energy building, a Living Building, and two LEED Platinum/2030-challenge compliant buildings. We then interviewed key project participants to identify successful process strategies that were used to achieve and, in some cases, outperform cost and performance goals. Unsurprisingly, a recurring theme throughout the twenty-five conducted interviews was the importance of team integration and collective alignment around team goals, though none implemented IPD in its truest form.

This report first explores the current state of IPD throughout practice, common perceptions of IPD, and where challenges have arisen. Each case study then explores how "IPD-ish" approaches were implemented in high-performance projects and how they benefitted cost-effective achievement of project outcomes, with a focus on energy performance.

METHOD

For each building, a series of individual interviews and surveys were conducted with the owner, architect, contractor, and, where possible, mechanical engineers and energy consultants. The survey results were used to develop "at-a-glance" summaries of the project timeline, which strategies were implemented, and how they were beneficial from the perspective of each participant. The text that supplements these summaries describes how strategies were implemented and the lessons that were learned in the process.

RESULTS

Teams are implementing a variety of IPD strategies to enhance team collaboration and cohesion. Early involvement of key participants, collaborative decision making, integrated team structures, and metrics-based decision making are among the most commonly implemented strategies. Implemented strategies and the extent to which they were found useful vary among project participants, even within the same project team.

Other common themes emerged from interviews with the project teams of the four different projects. These are briefly summarized below.

OWNER INVOLVEMENT

Higher levels of integration demand an experienced owner who brings clearly defined expectations and is willing to be involved from pre-design to handoff. Owners must dedicate significant staffing resources throughout the design and construction process, serving as the team's integrator and facilitator.

RISK AND FISCAL TRANSPARENCY

Particularly in high-performance buildings, where innovation is high and precedent is low, risk can be effectively managed through discussion and transparency. Cost increases due to larger contingencies can be avoided through open communication and resolution of misconceptions.

BEYOND DELIVERY: INTEGRATED OPERATIONS

IPD is an approach to project delivery; thinking more holistically and extending the philosophy to operations can smooth the transition at handoff. Teams have found that involving facilities managers in the design process is useful, but it is most important to establish a facilities liason to demonstrate building operations and answer questions during the tranisition from construction to occupancy.

IPD-ISH BENEFITS

IPD philosophies can be effectively applied to traditional contract structures and may serve as an intermediate step as industry progresses to a true-IPD approach. Teams are still conflicted about the necessity of implementing IPD contracts. Many teams are waiting on clear evidence of the proposed benefits of multi-party agreements.

LIVING BUILDING MATERIALS RED LIST

The materials red list requires extensive research and is best handled proactively. Product manufacturers require significant education about the Challenge criteria. The red list will likely be one of the most difficult components of the Challenge until manufacturers more willingly provide accurate data.

1.1 DELIVERING GREEN

Building codes and standards are growing increasingly stringent; clients are growing increasingly aware of and concerned about rising energy costs and their buildings' contributions to climate change. As a result, the market is shifting toward a higher demand for optimized energy- and water-efficiency in buildings. These higher-performing buildings require a holistic approach to the design process; as such, project teams must take more integrated approaches to project design and delivery. This shift is already occurring, as owners, contractors, and architects realize that the conventional design-bid-build [DBB] scenario is neither an efficient nor cost-effective approach to tackling the interdisciplinary complexity of a high-performance building.

Alternative delivery methods including Design-Build [DB] and Construction-Manager-at-Risk [CMR] are well established and widely implemented in practice. Slightly less common is the Construction Manager/General Contractor [CM/GC] scenario, in which the construction manager is hired early, usually based on qualifications and cost, and joins an integrated team, which together balances risk, cost, and schedule using phased bid packages.

Currently, integrated project delivery [IPD] is the latest and most progressive project delivery method in practice. IPD has been implemented in its purest form in few projects since 2005, and most of these have been in the healthcare sector. It is most often characterized by multi-party contract structures, enhanced team collaboration, and intensified early planning, though industry continues to search for a broadly accepted definition [Sive 2009, Thomsen 2010, Kent, et al. 2010, Bongiorni 2011]. IPD can range from minimally enhanced collaboration, to "IPD-ish", to "true" or "pure" IPD, depending on the strategies used [AIA 2010]. Typically, "true IPD" involves a multi-party agreement, while IPD-ish approaches treat IPD as a philosophy, often using some level of shared risk and reward [AIA, et al. 2010]. While not all IPD projects have rigorous sustainability goals, the method offers increased flexibility for owner outcomes, which may include high-performance.

IPD uptake has been slow, despite repeated promotion by many professional organizations [AIA 2007a,b, 2010]. Because many of the early projects employed multi-party agreements, there developed a belief that an IPD project must include some form of multi-party contract structure. This perception may partly explain the slow uptake: owners and practitioners are waiting for evidence of the proposed benefits before risking the change. This perceived need for multi-party contracts can be revisited. The primary goal of IPD is to create an environment that fosters collaborative decision-making and team alignment around shared goals; how this is achieved is in the hands of the project team. The need for IPD contract structures can vary from project to project and from team to team.

1.2 IPD: AN EVOLVING APPROACH

A comprehensive review of existing literature, including several publications from professional organizations, industry, and academia, indicates that the scope of IPD and its associated implementation strategies can vary from project to project. Figure 1 compares a traditional project timeline to a representative IPD timeline. As shown in the figure, IPD typically intensifies the early phases of the design process, bringing key participants to the table as early as the pre-design phase. These key participants co-locate after building foundational relationships and establishing project goals. IPD team structures also differ from traditional approaches. A project management team, consisting of representatives from the owner, architect, and contractor, meet weekly and are responsible for project scheduling, budgeting, and day-to-day decision-making. The project implementation team is responsible for designing, detailing, and constructing the project.

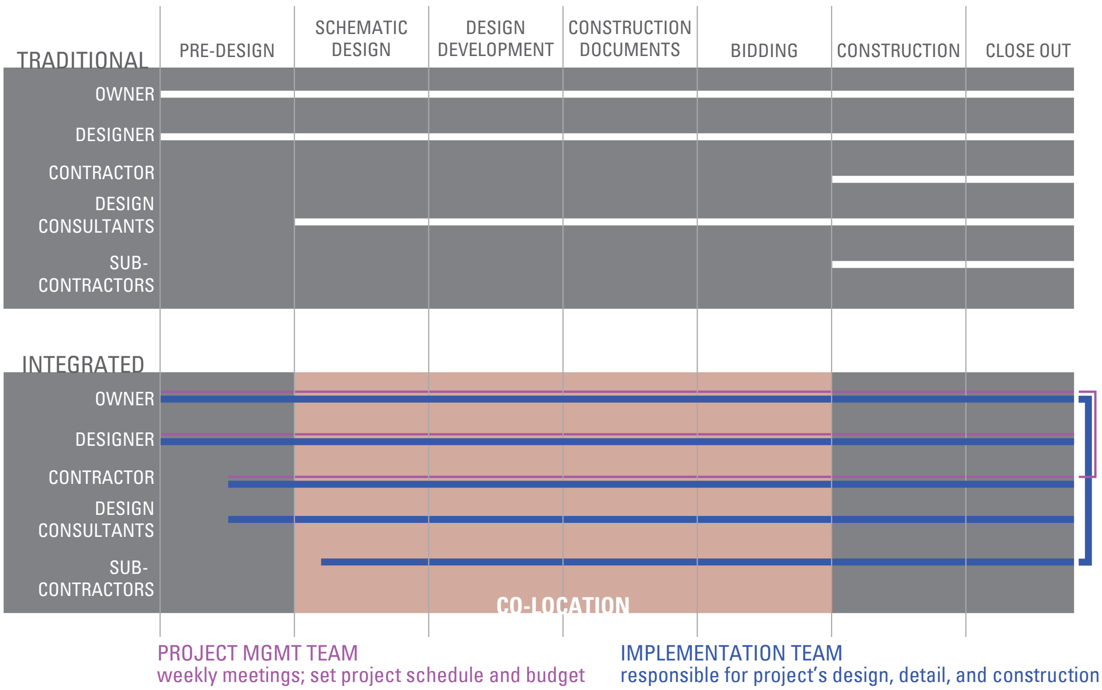


Figure 1. A traditional project timeline compared to a common IPD timeline. Co-location is most effective when applied after foundational relationships have been established. Project management team members meet weekly and are responsible for day-to-day decisions.

Figure 2 summarizes commonly referenced IPD implementation strategies. Strategies were extracted from twelve frequently cited journal articles and industry publications about IPD. The figure shows considerable variation from publication to publication, though four appear somewhat regularly: collaborative decision-making, shared financial risks/rewards, early involvement from key participants, and multi-party agreements.

	AIA, 2007a	AIA, 2007b	Autodesk, 2008a	Autodesk, 2008b	DeBarnard, D.M., 2008	Sive, T. (2009)	Cohen, J. (2010)	Kent, D.C., et al. (2010)	Thomsen, C., et al. (2010)	Bongiorni, M.J. (2011)	Ghassemi, R., et al. (2011)	Cheng, R., et al. (2012)
Collaborative decision making		■	■	■	■	■	■		■	■	■	■
Shared financial risks/rewards	■	■			■	■	■	■	■	■	■	■
Early involvement by key participants		■	■	■	■	■	■	■	■	■	■	
Multi-party agreement					■	■	■	■	■		■	■
Open communication	■		■		■		■			■		■
BIM [or shared models]				■	■	■	■					■
Jointly developed goals	■		■				■			■	■	
Mutual trust and respect	■		■	■			■			■		
Liability waivers						■	■				■	■
Leadership			■						■	■		■
Intensified early planning			■			■	■			■		
Appropriate technology	■	■	■							■		
Lean construction processes					■	■	■					■
Target value design		■			■	■						
Relational contracts						■						■
Fiscal transparency							■					■
Co-location							■					■
Metric-based decisions	■					■						
Early identification of risk												■
Existing relationships between parties												■
Legal relationships [unspec.]				■								

Figure 2. Tabular summary of IPD implementation strategies. Strategies, listed vertically in the left-most column, are organized by frequency of occurrence, while citations, listed chronologically from left to right, are shown in the top row.

1.2.1 IPD: PERCEIVED BENEFITS

The intensified collaboration and interdisciplinary approach of IPD render the method very suitable for cost-effective, efficiently built, high-performance buildings; oddly, the literature rarely explicitly addresses IPD's benefits for green buildings.. Many high-performance project teams use several of the strategies listed in Figure 2 in conjunction with more conventional contract structures; thus, the leap to true IPD may not be as great as is commonly perceived. Figure 3 summarizes commonly perceived benefits of IPD in the literature.

	AIA, 2007a	AIA, 2007b	Autodesk, 2008a	Autodesk, 2008b	DeBarnard, D.M., 2008	Sive, T. (2009)	Cohen, J. (2010)	Kent, D.C., et al. (2010)	Thomsen, C., et al. (2010)	Bongiorni, M.J. (2011)	Ghassemi, R., et al. (2011)	Cheng, R., et al. (2012)
Optimized efficiency	■		■	■		■				■		■
Improved sustainability				■					■			■
Reduced waste	■		■									
Increased value			■		■							
Increased innovation				■						■		
Optimized owner outcomes			■									

Figure 3. Tabular summary of perceived benefits of IPD. Benefits, listed vertically in the left-most column, are organized by frequency of occurrence, while citations, listed chronologically from left to right, are shown in the top row.

The benefits listed above describe how the project improved as a result from the IPD process, as described in the literature; however, as shown in Figure 2, the IPD process can take on a range of characteristics, depending on the strateiges implemented. Unsurprisingly, the variation described in Figure 2 is reflected in practice as well. There are a variety of IPD strategies commonly used by project teams, each implemented in slightly different ways, with varying results. Implemented strategies and the extent to which they were found useful are shown in Figure 4. A small color block is shown if the strategy was implemented. Blocks extruded upward indicate that the strategy was among the three most beneficial to the project delivery process while blocks extruded downward indicate that the strategy was among the three least beneficial to the project delivery process. Colors indicate the project team member reporting.

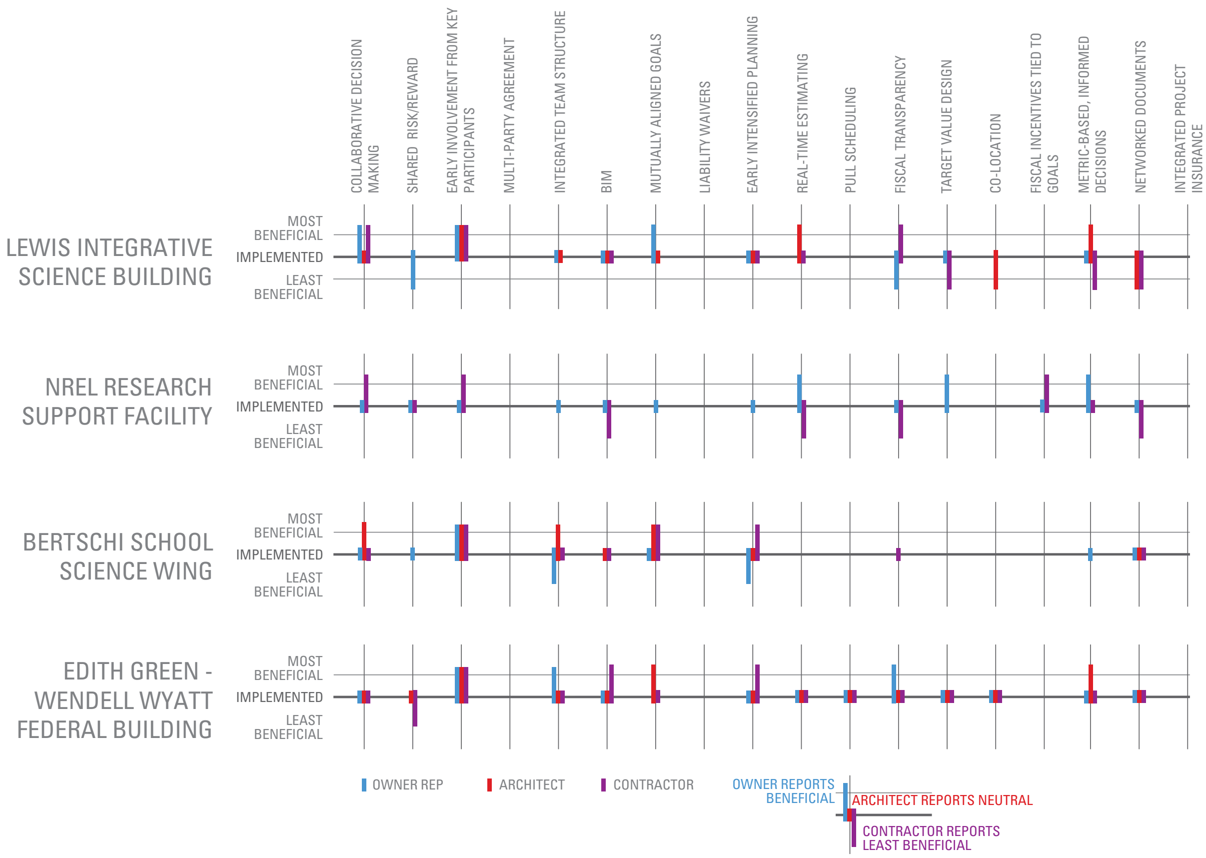


Figure 4. There is strong agreement among the four case study projects as to which implementation strategies are most beneficial. Collaborative decision making, early involvement of key participants, and metrics-based decision-making are repeatedly reported as beneficial strategies by project participants.

Common themes emerged from this comparison of implemented strategies. Collaborative decision making, early involvement of key participants, and metrics-based decision making are repeatedly reported as beneficial strategies by multiple project participants. These themes agree closely with the strategies most commonly referenced in Figure 2. It is interesting to note, however, that not all themes are unanimously described as beneficial or least beneficial among project team participants. For example, in the case of real-time estimating for NREL Research Support Facility, the owner found the strategy to be among the most beneficial to the project, while the contractor found it to be among the least beneficial. This does not necessarily mean that the strategy is less important; however, it does indicate that team members should recognize that certain steps may seem unnecessary to their work but highly beneficial to another team member's work, and, in turn, highly beneficial to the project.

It should also be noted that comparing among the four projects assumes that each project implemented the strategies in the same way. As the case studies reveal, project teams took different approaches in implementing these strategies and consequently observed a range of benefits.

1.2.2 IPD: CURRENT STATUS - WHY THE SLOW UPTAKE?

Broad adoption of IPD lags despite wide promotion by both AIA and AGC. Research indicates that practitioners are staying away from IPD simply because they have yet to see the evidence backing the supposed benefits [Kent and Becerik-Gerber 2010]. Furthermore, many are familiar with the strategies of IPD, but few are sure of how they are truly implemented.

The following section examines how the theoretical approaches listed in Figure 2 currently manifest themselves in practice. The summary draws from information from interviews with practitioners and from publications from industry and academia.

COLLABORATIVE DECISION MAKING

"We're getting further away from 'we design it, you price it and build it.' The subcontractors are becoming a sounding board for the design team."

Mark Butler
Contractor
Lease Crutcher Lewis
Portland, Oregon

IDEAL

Leadership structures are tiered: typically this includes a core team of representatives from the owner, architect, engineer, and builder who meet weekly throughout planning, design, and construction and a field team of mid-level participants who meet more frequently to resolve day-to-day issues. There may also be a third, executive-level tier, which meets less frequently to resolve any issues from the core team.

CURRENTLY IN PRACTICE

Teams are modifying this structured approach to suit the needs of specific projects. In some cases, subcontractors or energy consultants may augment the core team as needed to assist with specific aspects of the project. In many cases, teams report that the structured approach is most successfully implemented when participants are willing to blur traditionally defined professional boundaries [Cheng, et al. 2012].

COMMON CHALLENGES IN PRACTICE

The tiered approach requires considerably more involvement and knowledge from the owner, with higher meeting frequency and more decision-making responsibilities.

SHARED FINANCIAL RISK/REWARD

"Having a shared incentive throughout the project for excellent performance or meeting/going beyond the requirements helps get people to put the time in. Performance should be incentivized."

Tom Hootman
Architect
RNL Design
Denver, Colorado

IDEAL

Collaboration is incentivized through shared risk/reward pools in which all key participants have a stake. The shared incentive pool draws the focus from individual participants' goals to the shared goals of the project.

CURRENTLY IN PRACTICE

Some project teams are using performance-based incentive structures and shared incentive pools to quickly establish team collaboration. Practitioners disagree about the effectiveness of shared risk/reward scenarios [Kent and Becerik-Gerber 2010].

COMMON CHALLENGES IN PRACTICE

Teams have had difficulty finding insurance products to cover unique joint-liability schemes. Some argue that monetary incentives are not the most effective way to foster team collaboration and can lead to more blame than conflict resolution [Kent and Becerik-Gerber 2010, Cohen 2010].

EARLY INVOLVEMENT OF KEY PARTICIPANTS

"With the Living Building Challenge, everything is tied together, so everyone has to be involved from the beginning. Contractors and subcontractors need to be there to answer questions."

Chris Hellstern
Architect
ZGF [formerly of KMD]
Seattle, Washington

IDEAL

Participants are involved from the earliest practical moment. The benefits of combined experience and expertise are most evident during the early stages of a project. Early involvement and intensified effort saves time and money during later project phases.

CURRENTLY IN PRACTICE

This is being widely adopted, particularly in high performance projects, where program and ambitious energy and water targets already demand early involvement and expertise. Research indicates that the majority of integrated projects are involving subcontractors, manufacturers, and specialty consultants from preliminary design through design development [Kent and Becerik-Gerber 2010]. Consultants and suppliers are typically less involved at project closeout. Interviews with practitioners agree with both of these findings.

COMMON CHALLENGES IN PRACTICE

None found.

MULTI-PARTY AGREEMENT

"At least on the public side, the tri-party agreement is very problematic from a regulatory perspective. The challenge is to re-define IPD, which shouldn't be defined by contract form. What's important is the ability to work as, and within, a team format."

Patrick Brunner
Owner representative
US GSA Region 10

IDEAL

Key participants sign a multi-party agreement or form a single-purpose entity to shift the focus of interest from the individual to the project.

CURRENTLY IN PRACTICE

Implementation of the multi-party agreement has been very limited, and because it is so new, it has not yet been tested in court. Many view the multi-party agreement as a requirement and as a reason to dismiss IPD, particularly in large public institutions where contract structures are regulated. There has yet to be a demonstrated direct relationship between implementation of the multi-party agreement and improved project outcomes. Practitioners from a range of disciplines agree that IPD philosophies are can be applied to traditional delivery methods [Kent and Becerik-Gerber 2010], and this is reflected in many recent projects in which IPD philosophies are applied to modified D/B or CM/GC contracts [Ghassemi and Becerik-Gerber 2011, Cheng, et al. 2012].

COMMON CHALLENGES IN PRACTICE

Paradigm shifts in legal structures are generally slow, especially for public institutions in which contractual changes are legislative issues. Furthermore, the benefits of contractual agreements have yet to be proven with any certainty.

"On the most successful projects of my career, it's really about the team. The team recognizes that for the project to be successful, one problem has to be everyone's problem. This requires support and communication."

Bruce Johnson
Engineer, HDR, Inc.
San Francisco, CA

OPEN COMMUNICATION

IDEAL

Team performance depends upon open and honest communication. Disputes are acknowledged and resolved as they occur, with zero-tolerance for establishing blame or liability.

CURRENTLY IN PRACTICE

The open communication environment can be enhanced by other implementation strategies such as co-locating and joint goal development. Open communication becomes a byproduct of other strategies, which establish the project-centric mentality. Shared technologies, such as BIM and networked documents, also enhance open communication.

COMMON CHALLENGES IN PRACTICE

How this occurs is very dependent upon who sits at the table. Some teams are made of inherently better communicators than others.

"BIM allows us to quickly convey information and to make sure that what we are selling matches what we are delivering. It allows complex problems to be solved in a universal way."

Jim Riley
Architect, SERA
Portland, Oregon

BIM

IDEAL

BIM is a living document to which all key participants can contribute.

CURRENTLY IN PRACTICE

Many contractor and subcontractors are not sufficiently trained in BIM to take full advantage of all that it has to offer. An under-detailed BIM model limits its practical use, and a sufficient detailed model requires input from the subcontractors, who are not yet using it universally. BIM's integration is evolving.

COMMON CHALLENGES IN PRACTICE

See "Currently in practice" above.

"The goals were established early with the users, owner representatives, MEP, and architects. In later meetings, we would always come back to the goals and re-present them. There would be some mistakes, but we learned. Each time we learned more."

Laurie Canup
Architect
THA Architecture
Portland, Oregon

JOINTLY DEVELOPED GOALS

IDEAL

The owner establishes the project's programmatic goals. The full team then works in pre-design to develop performance metrics, with the intent to shift interests from the individual to the project. These may include energy performance and occupant satisfaction metrics, as well as more traditional measures such as cost, schedule, and scope.

CURRENTLY IN PRACTICE

This is being successfully implemented in projects from "IPD-ish" to "true-IPD". This approach goes beyond the eco-charrette. It requires carefully establishing measureable goals, developing appropriate metrics to gauge their achievement, and weekly follow-ups to assess status. This is particularly true in complex, high-performance projects where intensified collaboration is required by the program. Some projects involve key participants in the initial programming and budgeting phases [Cheng et al., 2012].

COMMON CHALLENGES IN PRACTICE

Earlier involvement of team members requires higher resource investment upfront and willingness from owners to relinquish some control to the rest of the team.

"The team agreed we were going to lock arms and jump off the bridge together. There was some pain involved in that; part of the strategy was to garner the same commitment from our subcontractors."

Steve Clem
Contractor, Skanska
Portland, Oregon

MUTUAL TRUST AND RESPECT

IDEAL

Owner, designer, consultants, contractor, and subcontractors share a commitment to working as a team toward project-driven goals, which requires a high level of established trust and respect. If other IPD implementation strategies are properly implemented, the atmosphere will naturally be one of high mutual trust and respect.

CURRENTLY IN PRACTICE

It is hard to evaluate how successfully mutual trust and respect are cultivated, though project teams agree that a high level of trust is essential to successful IPD implementation and requires far more than the initial charrettes and partnering sessions that are common to current design processes.

COMMON CHALLENGES IN PRACTICE

There is general reluctance to break free from traditionally defined roles and ways of working; furthermore, the majority of practitioners do not see a need for improvement in this area [Kent and Becerik-Gerber 2010], which makes it difficult to motivate change.

LIABILITY WAIVERS

IDEAL

Key participants waive the possibility of litigation except in the cases of fraud, willful misconduct, or gross negligence. Mediation and arbitration are used if needed.

CURRENTLY IN PRACTICE

This has been implemented in very few projects, even within a pool of "true-IPD" projects [Cheng, et al. 2012, Cohen 2010, Ghassemi and Becerik-Gerber 2011].

COMMON CHALLENGES IN PRACTICE

This strategy requires an extremely high degree of trust among team members.

LEADERSHIP

IDEAL

Team leadership structures are tiered. All team members are committed to shared goals and values; thus, the team member best-suited for the task at hand takes the lead, rather than the traditionally established leader.

CURRENTLY IN PRACTICE

How this approach is successfully implemented in practice depends upon the cohesion of the team. Early involvement, pre-existing relationships between team members, and team building activities may help catalyze this blurring of standard leadership roles.

COMMON CHALLENGES IN PRACTICE

This approach requires a paradigm shift, as participants are required to move beyond traditionally defined professional boundaries. This requires strong mutual trust and respect among team members.

"It is a fundamental notion of integrated design: put more effort in early and save time and money later. It means doing more things in a workshop setting than in a presentation setting. Instead of designers making a pitch for a concept, you roll up your sleeves and develop concepts together."

Fred Tepfer
Owner representative
University of Oregon
Eugene, Oregon

"There are two major points about lean: people often focus on eliminating waste, but there's the other half, about maximizing value. Lean in design is about being clear about value with the client early on.

Laura Lesniewski
Principal, BNIM
Kansas City, Missouri

INTENSIFIED EARLY PLANNING

IDEAL

Early intensified planning shifts the efforts from the construction phase to the early phases of design, ideally to increase efficiency and savings during the later stages of the project. The goal is to minimize waste during the cost-intensive construction phase.

CURRENTLY IN PRACTICE

Projects with experienced owners and a team that is well integrated from the project's onset are successfully implementing early intensified planning and finding considerable benefits. Less cohesive teams led by less experienced owners see less benefit.

COMMON CHALLENGES IN PRACTICE

Early intensified planning requires a very involved, prepared, and experienced owner who can clearly express the project's goals and expectations. Most owners either do not have the experience or resources to successfully implement this approach.

LEAN CONSTRUCTION PROCESSES

IDEAL

Groups agree contractually to prioritize minimizing waste, construction time, and the expenditure of resources that do not create value for the end customer. Like IPD, lean considers the product, not the pieces [Cohen 2010].

CURRENTLY IN PRACTICE

Survey respondents report lean construction methods among the least important strategies for IPD success [Kent and Becerik-Gerber, 2010], while other reports that lean construction principles can add as much as 55% of the project value [Cohen 2010].

COMMON CHALLENGES IN PRACTICE

When asked about the extent to which lean principles were implemented in their projects, interviewed practitioners reported that they were implementing many lean approaches, but weren't formally identifying them as "lean". Whether or not they are truly adopting lean methods, these practitioners see little need for change.

RELATIONAL CONTRACTS

IDEAL

Relational contracts are seen as a transitional step between traditional and completely integrated legal structures. Liability is limited but it is not completely waived. Decisions are made collaboratively, but the owner has the final say. Compensation may include project-based incentives, but there may not be collective responsibility for cost overruns.

CURRENTLY IN PRACTICE

Most "True IPD" projects use relational contracts.

COMMON CHALLENGES IN PRACTICE

Industries are very slow to adopt broad paradigm shifts. Ultimately the decision to implement new contract structures comes from the owners, who are often wary or unaware of alternative delivery methods [Ghassemi and Becerik-Gerber 2011].

“Co-location helps simplify communication and create added value. It helps in relationship building too, but that normally follows witnessing, which is actually leveraging, the ‘relationship’ already developed.”
Patrick Brunner
Owner representative
US GSA Region 10

CO-LOCATION

IDEAL

Also known as the “big room”, key participants co-locate to a single office.

CURRENTLY IN PRACTICE

This has been implemented in a range of ways. In some cases, representatives from each of the key teams are able to share a single space, while in other cases, design firms working on joint-venture projects may temporarily share an office. Efficiency and increased team commitment and collaboration are reported benefits, though is not agreed upon by all participants [Cheng, et al. 2012].

COMMON CHALLENGES IN PRACTICE

Co-location requires reexamination of staffing methods. Co-located participants must dedicate all of their work hours on a single project, which is a sharp change from traditional multi-project staffing systems.

“The process needs to force teams to innovate to meet a budget. Designers can be integrated with estimators and sub-contractors who actually build it, and the design will be balanced with energy, cost and constructability.”.
Shanti Pless
Owner representative
NREL
Golden, Colorado

METRICS-BASED DECISIONS

IDEAL

Metric-based decision-making immediately brings project goals to the forefront and further contributes to collective project alignment over individual success and gain. Metrics-based decisions invariably result in improved project outcomes.

CURRENTLY IN PRACTICE

Depending on the priorities of the project, metrics-based decision-making can be essential to achieving high-performance cost-effectively. Gauging the feasibility and value of design strategies using both cost and energy models can be a very powerful approach.

COMMON CHALLENGES IN PRACTICE

This strategy requires a highly disciplined and technical team with the resources to accurately evaluate the implications of their decisions, as the strength of the decision is partially dependent upon the strength of the models that provide the feedback. It takes time to apply metrics. Additionally, some practitioners feel challenged by the possible loss of control over the design aesthetics.

EXISTING RELATIONSHIPS BETWEEN PARTIES

IDEAL

Existing relationships between parties catalyze the establishment of high levels of trust and comfort within the project team.

CURRENTLY IN PRACTICE

In some ways, this is happening by default, as firms with IPD experience become a limited segment of the industry. Teams do not report this as an essential component in IPD [Cheng, et al. 2012].

COMMON CHALLENGES IN PRACTICE

Cultivating relationships between parties and working with familiar teams limits the growth of IPD, as the experience and knowledge is not spreading among firms.

"Our approach was to share the risk and explore what would happen in the event of failure; this allowed us to hold an appropriate amount of contingency, and we didn't have to have redundancy in managing the risk."

Tom Hootman
Architect, RNL Design
Denver, Colorado

COLLABORATIVE DECISION MAKING

IDEAL

Early risk identification enables early establishment of shared/risk reward schemes and proper risk allocation.

CURRENTLY IN PRACTICE

This has been implemented in several ways, and teams report a range of benefits. Shared/risk reward structures resulting from early identification of risk seem to offer mixed results [Kent 2010]. Some teams hold early meetings that focus exclusively on perceived risks . These teams report that early and open identification of risk can result in considerable savings at bid. Often perceived risk is based on a conceptual misunderstanding. Risk transparency from early on can reduce risk-based bid cushions.

COMMON CHALLENGES IN PRACTICE

This approach requires open communication and mutual trust and respect among team members. The extent to which this occurs depends upon who is sitting at the table.

INTEGRATED PROJECT INSURANCE

IDEAL

If firms sign a liability waiver, then the need for first party insurance products is eliminated [AIA 2007a].

CURRENTLY IN PRACTICE

Firms are using contracts that fit within traditional insurance products or are finding ways to purchase insurance products that cover liability during both the design and construction phases of IPD projects [Ghassemi and Becerik-Gerber 2011].

COMMON CHALLENGES IN PRACTICE

The insurance industry will not develop IPD-specific products until the practice is well established; one of the major barriers to broad uptake to IPD is the question of insurance and risk management. It is a chicken and egg issue.

1.3 WHERE IPD STANDS WITH GREEN BUILDINGS

Much of the existing IPD literature understandably selects the studied projects based on their successful implementation of IPD. This report, instead, selects case studies based on successful project outcomes, specifically sustainability outcomes, and seeks to better understand how these outcomes were achieved. In each case, IPD was used to some extent, though not in its truest form. This report aims to assess the extent to which project teams are implementing IPD strategies and how these strategies are benefitting achievement of performance targets.

2.1 CASE STUDY SELECTION

We first assembled an internal database of over 150 high-performance buildings, collecting cost, energy use, and water use data for each project. Buildings were included in the database if they achieved of one or more pre-defined green standards, including Living Building Certification, LEED v2.2 Gold or higher, compliance with Architecture 2030, verified net zero energy performance, or AIA/COTE Top Ten selection. See Appendix 1 for further definitions of these criteria. Cost analysis was performed on these projects, and the results are available in a separate report.

Case studies were then selected from this database based on two criteria. First, projects were included based on exemplary cost, energy, or water performance within each building type. Second, the short-list of buildings was further narrowed to four based on practitioner and owner participation. Phone or in-person interviews were then arranged with representatives from the architect, contractor, and owner of each project. Where possible, mechanical engineers and energy analysts were interviewed as well.

2.2 INTERVIEWS

A bank of interview questions was developed prior to the interview process. Each project representative was asked a slightly different selection of questions, depending on their expertise and on already published information about the project. This bank of questions is provided in Appendix 2.

2.3 SURVEYS

A supplementary survey was distributed to each interview participant using Qualtrics survey software through the University of California, Berkeley Department of Psychology. The short, eight-question survey is listed in Appendix 2. It was used to gather basic yes/no information about each project, including which IPD strategies were implemented and the extent to which these strategies benefitted the project. The survey also asked for dates of achievement of common project benchmarks, including completion of drawing packages, cost estimates, LEED registration and certification [when applicable], and involvement of key participants.

CASE STUDIES

LEWIS INTEGRATIVE SCIENCE BUILDING

photo by Sara Tepfer

PROJECT DETAILS

LOCATION:	Eugene, Oregon
COMPLETION DATE:	October, 2012
SQUARE FOOTAGE:	103,000 sf
PROGRAM:	wet labs, dry labs, animal facility
DELIVERY METHOD:	construction manager/general contractor
TOTAL COST:	$65 million
EUI:	150 kBtu/sf
AWARDS + RATINGS:	tracking LEED v3.0 platinum Architecture 2030-compliant

BACKGROUND

Planning and design of the Robert and Beverly Lewis Integrative Science Building [LISB] at the University of Oregon demanded a collaborative approach from day one, both because of the integrated culture and the extreme technical complexity embedded in the building's program. The building was to exemplify the interdisciplinary values at Oregon, both programmatically, as a new home to several research groups exploring questions that are undefined by traditional departmental boundaries, and geographically, by linking four existing research facilities across a range of scientific disciplines. A dauntingly technical challenge, the building includes new lab space for chemists, biologists, neuroscientists, and behavioral psychologists, neuroimaging and nanoscale materials characterization facilities, and a vivarium.

LET NO BTU GO UNCHALLENGED

To further challenge themselves, the University set out to make LISB as energy- and water-efficient as possible, given the established budget. The project team immediately aligned themselves around ambitious energy and water goals. They quickly established the mantra, "Let no BTU go unchallenged," creating a collaborative environment that rigorously questioned business-as-usual approaches and sought continuous improvement from conception to construction. The result was the successful implementation of highly innovative solutions that tapped existing onsite waste streams for heat recovery and non-potable domestic water use.

BACKGROUND [continued]

JOINTLY ESTABLISHED PROJECT GOALS

The University established program priorities and an early budget that could support the ambitious energy performance goal of 40% better than ASHRAE 90.1-2004. The core project team, in addition to energy consultants, users, and facilities representatives, held an early meeting to rigorously evaluate and establish feasible sustainability goals, including systems integration, optimized daylighting, occupant education, and building monitoring. By involving all key stakeholders in the initial goal-setting meetings, the team was immediately aligned around the mission of the project as a whole, rather than their individual objectives. This initial set of goals was maintained throughout the project, later serving as a reference and accountability check for project team members. The team would return to the goals in each meeting, maintaining cohesion and continuously identifying lessons learned and areas for improvement.

LEED certification was not originally included in the project goals. Initially, the University was wary of the risks of expensive point-chasing; however, throughout the project there was continuous evaluation of business decisions associated with achieving LEED Platinum versus LEED Platinum-equivalent. Because of the design team's stubborn commitment to well-integrated energy and water efficiency measures, the design was tracking high-gold, and could likely reach platinum with little added cost. Ultimately the decision to commit to LEED came from user representatives, who felt that the recruiting and publicity benefits of certification outweighed the increased soft costs associated with registration and documentation.

NOTABLE ENERGY PERFORMANCE STRATEGIES

The design team first evaluated energy and water-efficiency approaches that would take full advantage of existing energy and water waste streams within the site boundary and beyond. Each approach was then evaluated for cost and energy performance, with constant ranking of the available options. High-ranking approaches were then more carefully vetted and optimized for cost-effective integration. The universal alignment toward clearly established and sufficiently challenging project goals established a culture of open innovation and contribution, where all ideas were on the table. The result was successful implementation of unprecedented energy- and water-conservation measures.

EXISTING WASTE STREAMS

LISB's supply air is heated to its final delivery temperature using waste heat from a district steam tunnel running through the site. Water rejected from a reverse-osmosis system in a neighboring lab facility supplies flushable fixtures. In both cases, the ideas came from several discussions between consulting engineers and facilities managers. "We've been making the tunnel heat suggestion for 25 years, and this is the first time it got a receptive audience," noted Fred Tepfer, an owner representative for the University. "It was a safe environment; it was safe to test any crazy idea."

NOTABLE PERFORMANCE STRATEGIES [continued]

PROGRAM-SPECIFIC SYSTEM DESIGN

Designing mechanical systems to be program-specific can also reduce energy loads. Because the building was to house such a wide range of functions, a one-size-fits-all approach was not appropriate. The project team looked at each function individually and evaluated different solutions with regard to both cost and energy. The result was a dedicated outdoor air system with passive chilled beams and operable windows in the areas in spaces that could tolerate greater temperature variance, with limited implementation of the more conventional VAV approach only in those areas requiring maximum climate control.

COST AND RISK MANAGEMENT STRATEGIES

EARLY INVOLVEMENT AND CLEARLY DEFINED GOALS

Interview participants unanimously agreed on the importance of clearly defined goals and early involvement from all key stakeholders. Early contractor involvement reduced construction time and costs thanks to design-phase resolution of constructability issues; furthermore, early contractor involvement allowed a metrics-based design process that used the cost and energy models iteratively to cost-optimize energy control measures. The contractor's cost model was reconciled with a third-party estimate in the middle and at the end of each design phase. The contractor also maintained an options log throughout the project to track new ideas and details in between estimates; this allowed the team to introduce late-phase, higher-cost alternates and add-ons where there was room in the budget.

RISK ALLOCATION STRATEGIES

The owner implemented several risk allocation strategies. Architects assumed performance-based risk through a 10% redraw contract clause: if any bid package is more than 10% over the pre-determined budget, then the architects were required to redraw at no cost and work collectively with the team to bring the project within budget. The architect also assumed risk through a pre-scheduled, mid-design development "wall freeze", after which any proposed changes to the floor plans must be proved to be essential to the project. This mandate virtually eliminated the risk of costly late design changes. The owner assumed risk through the late GMP; however, it was repeatedly noted that the cost benefits almost always outweighed the potential loss associated with this approach. Finally, a collective risk was assumed through a 10% cushion on each bid package, which self-insures the continuity and completion of the project.

COLLABORATION, INNOVATION AND EXPERIMENTATION

The quickly established collaborative design environment catalyzed the proposal of many innovative approaches. Many of LISB's energy- and water-efficiency measures relied upon innovative reapplication of well-established technologies. By approaching

COST AND RISK MANAGEMENT STRATEGIES [continued]

innovation in this way, the team reduced the capital costs while maintaining the advantages of resource savings over the building's lifecycle. Furthermore, the MEP consultants conducted extensive on-site testing to confirm the existing conditions were suitable for their proposed heat and water recovery systems. These proof-of-concept studies further validated the new approaches, creating a compelling case, reducing the perceived financial risk for all team members.

BENEFITS OF AN INTEGRATED APPROACH

PERFORMANCE

The energy benefits are clear: the original goal was 40% better than ASHRAE 90.1-2004; the modeled energy use is almost a 60% improvement from 90.1-2004, and the building is currently performing more efficiently than was predicted by the model. Furthermore, the building far outperforms lab facilities with comparable ventilation loads. The energy analyst had previously seen minimum EUIs between 190 and 230 kBtu/ft^2 in comparable facilities.

MARKET VISABILITY

Both the contractor and architect acknowledged the market benefits to successfully completing such a technical feat. "Each challenge that we overcome, we're apt to go after more technical and more challenging projects," Mark Butler, of Lease Crutcher Lewis said. "With each new project, I'm trying to establish that collaborative relationship and always be available to the design team and owner throughout the design process."

LESSONS LEARNED

RESOURCE-CONSTRAINED PROGRAMMING

The team learned that the owner and architect must work together to prioritize resource constraints during building programming phase and allow the budget to guide the process. This requires early programmatic clarity and commitment from the owner, which, as was learned, is not an easy task in a complex university building. It also requires discipline on the part of the architect to design realistically, within the allowable budget.

COMMISSIONING AND AFTERCARE

The team found it essential to provide sufficient funding for thorough commissioning and aftercare, particularly in highly technical buildings. As is true of many projects, there were several problems in the programming of the building management system [BMS], requiring a collaborative de-bugging effort between the engineers and the BMS programmer. Allowing room in the budget to bring consultants back, not only to ensure the systems are working as designed, but also to further improve performance through fine-tuning, can result in high operational savings. Skipping commissioning and aftercare, the owner noted, renders useless all of the upfront investment in energy efficiency.

LESSONS LEARNED [continued]

WHY NOT TRUE IPD?

Team members agreed that the project would have seen little benefit from implementing a true-IPD, multi-party contract, as collaboration and alignment was already so strong. The team agreed that strong owner commitment, clarity of goals, and a common commitment for continual improvement created an atmosphere for integrated innovation. Contractual mandates would have been formalities.

RESOURCES

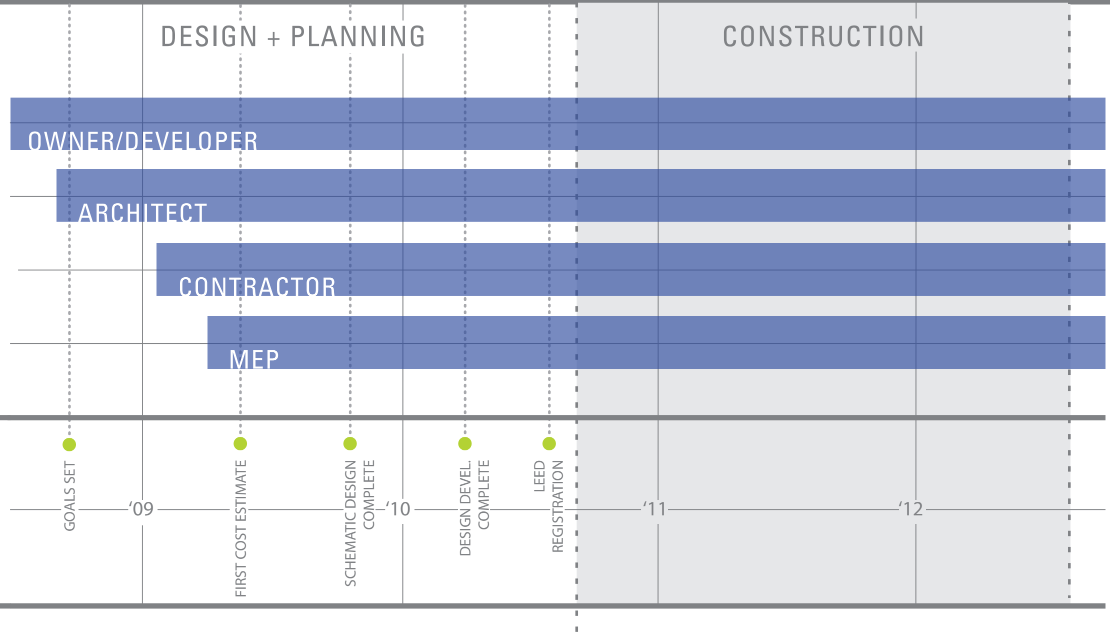
Architect:	Laurie Canup, Thomas Hacker Architects
Contractor:	Mark Butler, Lease Crutcher Lewis
Energy Analysis:	Mitchell Dec, Glumac
MEP Consulting:	Bruce Johnson, HDR, Inc.
	Dave Knighton, Balzhiser Hubbard Engineers
Owner Representatives:	Fred Tepfer, University of Oregon
	Emily Eng, University of Oregon

LEWIS INTEGRATIVE SCIENCE BUILDING

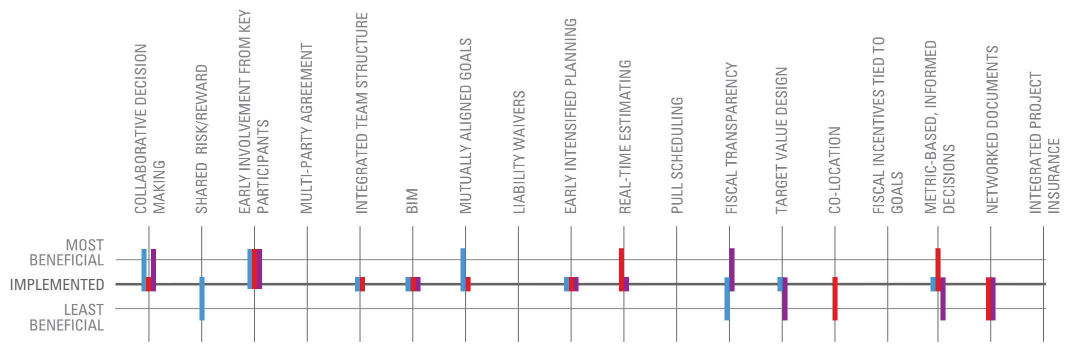
SUMMARY

INVOLVEMENT TIMELINE

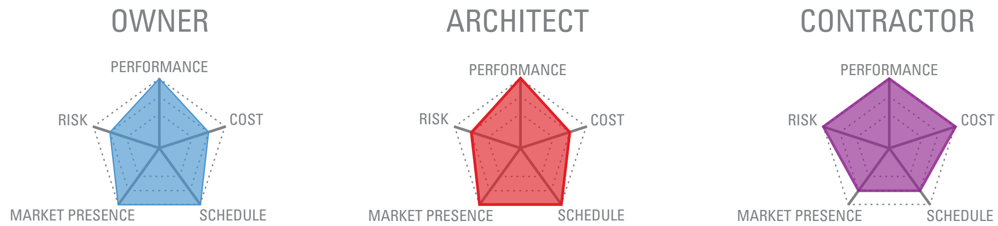
PROJECT MILESTONES



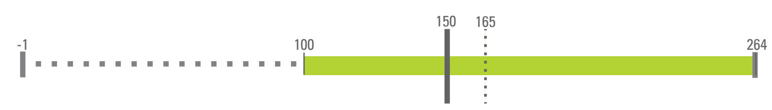
PROJECT DELIVERY IMPLEMENTATION STRATEGIES



PERCEIVED BENEFITS OF PROJECT DELIVERY IMPLEMENTATION STRATEGIES

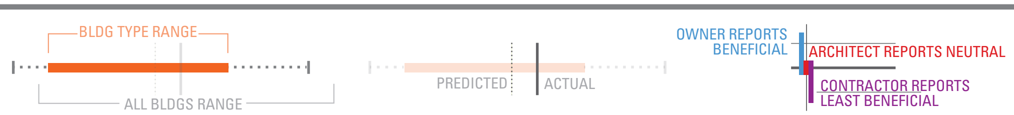


EUI [kBtu/ft² yr]



COST PER SQUARE-FOOT [$/ft²]

KEY



NREL RESEARCH SUPPORT FACILITY

photo by Dennis Schroeder. courtesy of NREL.

PROJECT DETAILS

LOCATION:	Golden, Colorado
COMPLETION DATE:	October, 2011
SQUARE FOOTAGE:	360,000 sf
PROGRAM:	offices, data center
DELIVERY METHOD:	performance-based design-build
TOTAL COST:	$91.4 million
EUI:	31.7 kBtu/ft^2 [including PV: -1.2 kBtu/ft^2]
AWARDS + RATINGS:	net-zero energy
	LEED Platinum
	AIA/COTE Top Ten 2011

BACKGROUND

For NREL, the Research Support Facility [RSF] project was an opportunity to challenge the notion that net-zero energy performance is too costly relative to standard construction. The team sought to create value in part by optimizing the acquisition and delivery process. The resulting firm-fixed-price, design/build scenario allowed NREL to develop performance specifications to describe what the building should do, and it allowed the designer/builder to determine the most cost-effective solutions to meet those criteria.

The owner implemented a two-part best-value selection strategy to assemble the design-build team. They used an RFQ process to short-list three project teams, and held interim interviews with each team during a collaborative RFP development phase to build trust and answer questions about the project. The finalized RFP contained a prioritized list of 26 performance objectives, painting a clear picture of project goals and expectations. The project team was selected based on their achievement of the prioritized objectives within the established budget. Though the approach required considerable upfront planning from all participants, it allowed NREL to leverage their own expertise early while leaving plenty of room for innovation and creativity for the design team.

BACKGROUND [continued]

CLEARLY DEFINED PROJECT GOALS

NREL made it clear from the beginning that the energy performance goal was as important as the cost and schedule drivers for the project. "The goal was embedded in the contract structure," said Tom Hootman of RNL Design. "This had a way of leveling the playing field as far as how decisions were made." It also resulted in strong team alignment, inspiring key participants to work together aggressively and collaboratively toward achieving the clearly defined performance targets.

Sustainability goals were incorporated into each of the traditional project goals [cost, schedule, and program]: the team considered not just first costs but the value of energy performance; the group balanced the speed and costs of construction with operations costs; and the RFP included minimized energy use as a programmatic goal.

NOTABLE ENERGY PERFORMANCE STRATEGIES

Successfully integrating cost-effective energy conservation measures was among the highest priorities for the project. The design/build team implemented several strategies to achieve this goal.

CLIMATE-DRIVEN PROGRAMMING

The design/build team had to take a holistic approach in the programming phase to achieve each of the design objectives within budget. The team first identified the energy strategies appropriate to the climate, and then began to think programmatically. This metrics-driven design effort evolved into an iterative process involving architects, MEP consultants, contractors, and LEED consultants. Iterations were evaluated for both cost and energy efficiency using evolving predictive models that were used consistently from the very beginning of the design phase through to project handover.

These energy conservation measures went well beyond system upgrades. The team achieved substantial reductions by implementing well-established passive-design principles, optimizing orientation and massing, passive heating and cooling strategies, envelope performance, and daylighting.

EARLY VALUE ENGINEERING

The project team went through an extensive value engineering process early, rather than at the end of design. "A value engineering process should actually add value; it shouldn't be a series of surprises at the end of design," noted Shanti Pless of NREL. To avoid the typical late cost-cutting process, the team proactively integrated design, constructability, and MEP cost estimating very early on. The result was cost-optimized, well-integrated energy solutions. "Whether it's a cafeteria or a research lab, we've been able to get a lot of scope because the value engineering process happened real-time in early design," Pless described.

COST AND RISK MANAGEMENT STRATEGIES

RISK TRANSPARENCY

The team managed risk through a collective commitment to transparency. For particularly innovative strategies, the common approach to managing risk is to add contingency. Instead, participants sought to understand the perceived risk associated with any proposed strategies, and where necessary, to correct any misconceptions. By being open and honest about risk, the team was able to successfully integrate highly innovative approaches without the added costs associated with more conservative contingencies.

EARLY INTENSIFIED PLANNING/FIRM FIXED PRICE

Early planning with the owner and contractor clarified the expectations and priorities of the project and identified and allocated risks within the team. The scope, schedule, and cost then formed the basis of the firm-fixed price [FFP], which was established at the end of the preliminary design phase. Setting the early FFP required the design/build team to be extremely diligent about cost. The group prioritized areas for funding and allocated resources accordingly.

AWARD FEE STRUCTURE

NREL implemented an award fee structure to encourage continuous open communication and team integration and alignment. The shared incentive for design and construction was allocated based on achievement of predetermined, measurable criteria at the end of each project phase. Though the contractor found the incentive extremely motivating, the shared incentive approach was not deemed essential to project success. The contractor found the open feedback sessions and clear evaluations as motivating and beneficial as the financial incentives.

BENEFITS OF AN INTEGRATED APPROACH

PERFORMANCE

Interview participants unanimously attributed the RSF's unprecedented energy performance to the integrated delivery approach. The team was able to cost-effectively minimize energy use through an optimized balance of both architectural and systems-based solutions. Based on performance data from 2010-2011, the RSF is running at 42% better than a typical office building. Adjusting for increased occupancy density and without accounting for rooftop PVs, the project is running at 31.75 kBtu/ft^2/yr, just under the goal of 35.1 kBtu/ft^2/yr. The building achieves its targeted net-zero energy goal with rooftop PVs.

COST SAVINGS

NREL RSF was built in two phases. Immediately after completion of the first two wings of the building, a third, nearly identical wing was added. This gave the project team a rare opportunity to optimize their delivery process for cost and performance. The results were staggering, as the third wing was roughly 11% more efficient and cost $14/ft^2

BENEFITS OF AN INTEGRATED APPROACH [continued]

less to build. These cost savings were equivalent to the cost of the rooftop PV array that would ultimately bring the project to net zero energy. This result is particularly interesting, as it indicates that the cost of renewables, one of the perceived barriers of net zero buildings, can be resolved through modifying existing inefficiencies in process.

LESSONS LEARNED

OPEN COMMUNICATION

The progressive delivery method required a new approach to organizational behavior, as many project details and decisions were negotiated among many members of the design team. Most key participants were on site daily and attended weekly project meetings, both to maintain open communication and trust within the team and to foster a sense of personal ownership and commitment. Participants noted that such communication is key, even to the subcontractor level. Key team members would meet with subcontractors on site to communicate expectations and details specific to the performance goals.

COMMISSIONING AND COLLABORATIVE OPERATIONS

The team learned the importance of planning for systems not to work and budgeting for it. This is particularly important in net zero energy projects. It is essential to budget for commissioning beyond the current industry standard and to budget for continuous metering. Metering data and energy models can be used to fine-tune operations targets. Any additional commissioning requirements should be clearly defined in the RFP. If building systems are not performing as intended, then the financial benefits of any initial investments are reduced.

There is much discussion in practice about the extent of facilities managers' involvement in the design process. NREL found that facilities managers' presence through the process was less important than was assigning a team representative to serve as a conduit to train the facilities manager for several months post-occupancy. This is particularly important in net zero energy projects, which typically implement innovative, high occupant-engagement systems that often require longer training periods for facilities managers.

WHY NOT TRUE IPD?

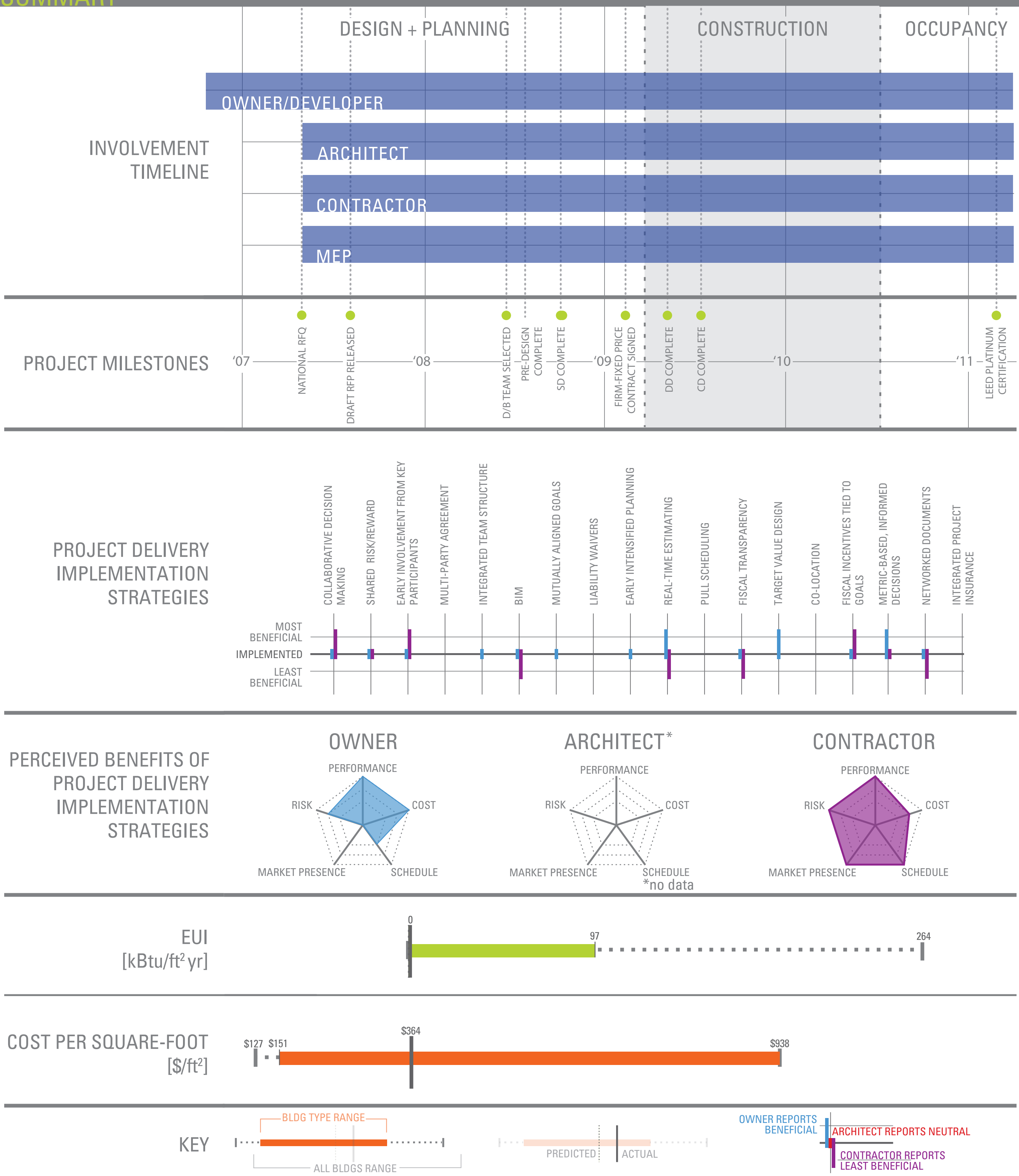
The firm-fixed price with performance-based design/build method seemed the most compelling way to ensure that the design would be balanced with energy, cost, and constructability. The owner felt that the IPD contracts do not guarantee cost-efficiency and performance to the same extent as the modified DBIA contracts. The approach was to instead apply collaborative philosophies to the design/build structure and use an award fee structure to maintain motivation and a spirit of continuous improvement for the design/build team. The team attributes project success partially to the contract structure, partially to incentives, and partially to the collective inspiration to achieve the project goals.

RESOURCES

Architect:	Tom Hootman, RNL Design
Contractor:	Jerry Blocher, Haselden Construction
MEP Consulting:	John Andary, Integral Group [formerly Stantec]
Owner Representatives:	Shanti Pless, NREL

NREL RESEARCH SUPPORT FACILITY

SUMMARY



THE BERTSCHI SCHOOL SCIENCE WING

photo by Benjamin Benschneider. courtesy of Chris Hellstern

PROJECT DETAILS

LOCATION:	Seattle, Washington
COMPLETION DATE:	February, 2011
SQUARE FOOTAGE:	1,425 sf
PROGRAM:	k-12 classroom
DELIVERY METHOD:	contract manager/general contractor
TOTAL COST:	$935,000
EUI:	48.1 kBtu/ ft^2 [including PV: 0 kBtu/ft^2]
AWARDS + RATINGS:	certified Living Building net-zero energy

BACKGROUND

Seattle's Bertschi School Science Wing was among the first certified Living Buildings in the world. The design team self-assembled in the spring of 2009 to pursue a Living Building project, motivated by an inspiring Living Future Conference; the only piece the team lacked was a project. The group made a successful pitch to the Bertschi school, a private school in Seattle known for its ambitious green building projects and for previously completing one of the first LEED Gold classroom buildings in the country. The team's proposal for a new science classroom and garden was simultaneously irresistible, risky, and extremely challenging, as it was the first of its kind, and it was to be designed pro bono and constructed entirely with community fundraising.

JOINTLY ESTABLISHED PROJECT GOALS

The rigor of the Living Building Challenge required close integration and collaboration from the project's early stages. Team alignment toward project goals was immediate, as the Living Building target was the original project driver. Furthermore, it was in all parties' interests to minimize costs because of the project's pro bono nature.

NOTABLE ENERGY PERFORMANCE STRATEGIES

HEALTHY MATERIALS, HEALTHY BUILDING

Red List compliance minimizes the occupants' risk of exposure to hazardous chemicals. This was particularly important to owner representatives, as the creation of a healthy space for learning was among the key drivers for pursuing the rigorous standards of the Living Building Challenge [LBC]. This LBC requirement was also among the most difficult to achieve.

NET-ZERO WATER

The team took advantage of Seattle's wet climate to achieve net-zero site water use. This was achieved through a rooftop collection system with storage cisterns, an interior green wall for greywater treatment, and composting toilets for blackwater treatment. Serving conceptual and programmatic goals in addition to their Living Building goals, the water treatment systems are featured prominently and are frequently integrated into classroom curriculum.

COST AND RISK MANAGEMENT STRATEGIES

EARLY INVOLVEMENT AND TEAM COMMITMENT

Interviewed participants unanimously agreed on the importance of clearly defined goals and early involvement from all key stakeholders. The owner implemented a modified AIA contract, adding language to address the notion of Living Building certification. The contract required the architect to stay on board through the certification process, minimizing risk to the owner. Early contractor involvement enabled design-phase resolution of constructability issues. This greatly reduced construction time and costs. These hard cost savings were key, as they somewhat offset soft costs associated related to certification-associated research. Because of the first-time nature of the project, the team adopted an "all-for-one" mentality: "We agreed we would lock arms and jump off the bridge together," said Steve Clem, a contractor with Skanska. Other interview participants agreed, attributing the project's certification to this unwavering commitment to achieving Living Building status.

ALIGNING AND EDUCATING SUBCONTRACTORS

A component of Skanska's preconstruction services contract required them to get continuous feedback from the subcontractors. These meetings allowed key participants to encourage a very high commitment level and understanding of goals from each of the subcontractors. Additionally, this alignment allowed the subcontractors to better understand the nuances of the Living Building Challenge, to be motivated to think beyond their traditionally defined roles, and to self-perform small tasks.

COST AND RISK MANAGEMENT STRATEGIES [continued]

MATERIALS DUE DILIGENCE

The Red List required significant manufacturer education. The team developed a questionnaire to distribute to manufacturers, explaining the Living Building Challenge and the materials data it required. The team first simplified this process, eliminating any unnecessary finishes or synthetic materials from the design. Still, obtaining reliable data for the most granular components of mechanical and electrical systems proved to be particularly difficult. Evaluating and using the data to then make informed decisions added another challenge. The design team dedicated significant research time to this task and acknowledged that a clear understanding of performance, warranty, and red list criteria was required to prevent significant project delays.

BENEFITS OF AN INTEGRATED APPROACH

ACHIEVEMENT OF OVERALL GOALS

Interview participants attributed Bertschi's successful certification to the collaborative environment that was fostered by early involvement and continuous individual alignment toward collective goals. This did not stop with the key participants. Each of the interviewees indicated the importance of involving subcontractors early and often, both for feedback and constructability concerns.

MARKET VISIBILITY

For Skanska, this project moved from a somewhat covert pet project to a full-feature on the international company's homepage. The project has resulted in Skanska's strong commitment to both the Living Building Challenge and the materials transparency movement as well as the firm's selection on other Living Building projects.

Bertschi students are seeing benefits of the project, learning directly from the building's sustainable features. Real-time energy performance data and prominently featured water conservation systems allow students to visualize the impacts of their interactions with the built environment.

LESSONS LEARNED

BUDGET TIME AND MONEY FOR THE RED LIST

Because the building was among the first of its kind, the design team underestimated the extensive research and materials vetting required of the Red List. Using the 2009 Living Building Financial Report [McLennan, et al. 2009] as a guide, the team estimated a 2.5% increase above the market cost for materials. Because of the small size of the building, the actual percent premium was considerably higher than this estimate. Interview participants agreed that treating the red list proactively, and researching materials in the early stages of design, would save resources and stress during the construction phase. "Figuring out the red list is going to be a steep learning curve for all contractors and

LESSONS LEARNED [continued]

designers, as well as for product manufacturers" acknowledged Bertschi campus planner Stan Richardson. "It took a lot of staff time, but that should improve with time."

WATER TREATMENT

Maintaining greywater and blackwater treatment systems overtime is quite resource-intensive. Until the technology improves and market adoption increases, the operating costs of these systems may be significant barriers to future Living Building projects. Project teams must budget not only for their operation, but for the facilities managers' necessary education on these specialized systems.

LEARNING LBC

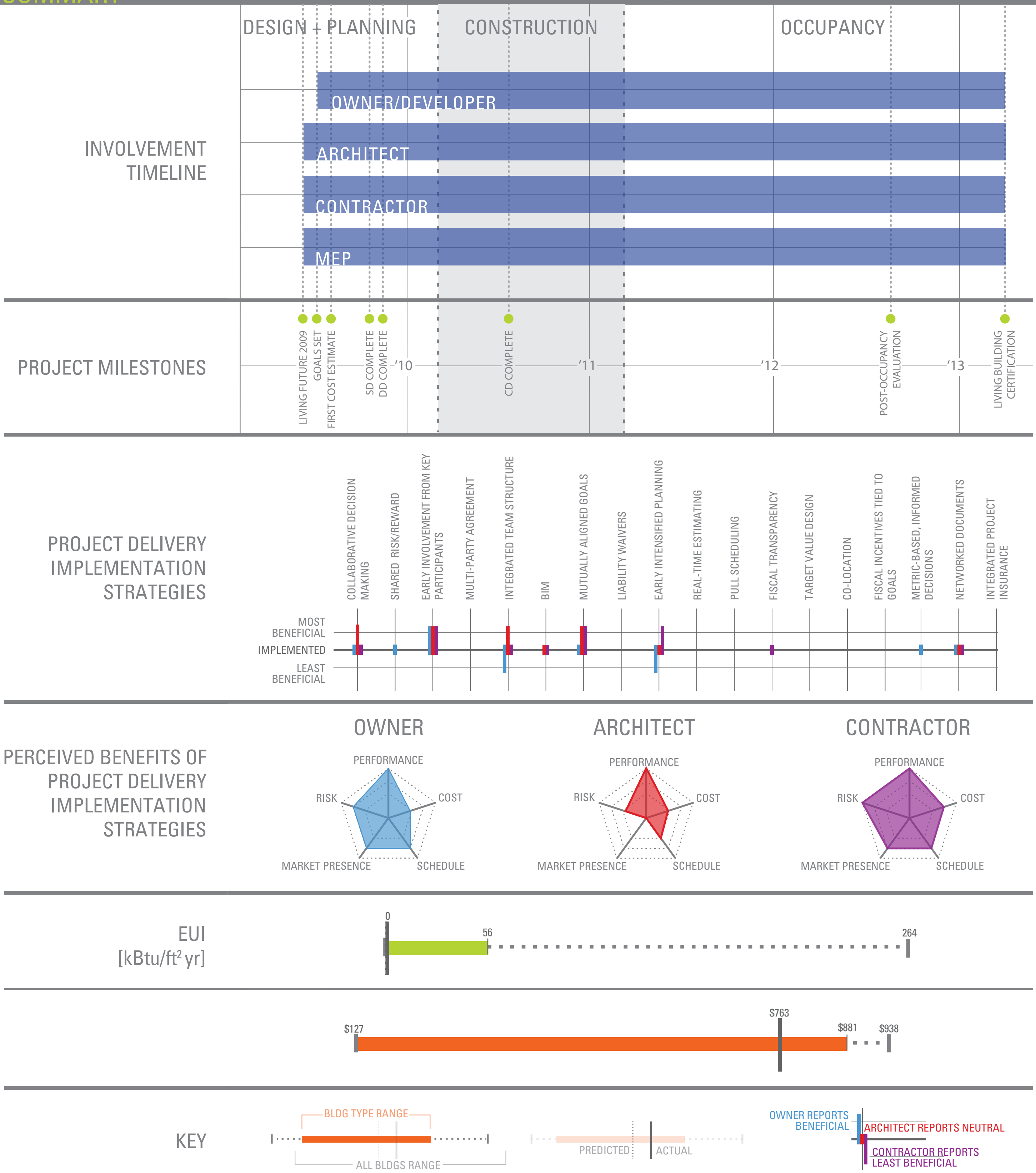
The team acknowledged a necessary commitment to learning throughout the design and construction of a Living Building. The rigor of the standard required each of the involved parties to step beyond traditionally defined roles. This may represent an initial cost barrier for the Living Building Challenge; however, this should improve as the Living Building Challenge becomes more broadly adopted. Furthermore, as they learn more about the Challenge, contractors and subcontractors will be less conservative in their bids. In the case of Bertschi, because the contractors had no prior experience with a Living Building, many of the bids came back considerably higher than Skanska's initial estimates. Similar to what was observed with LEED, this should improve with broader market adoption and increased professional experience with the Challenge.

RESOURCES

Living Building Case Study. International Living Future Institute. 2013. <http://living-future.org/case-study/bertschiscience>

Architect:	Chris Hellster, ZGF [formerly of KMD]
Contractor:	Steve Clem, Skanska
Owner representative:	Stan Richardson, The Bertschi School

THE BERTSCHI SCHOOL SCIENCE WING
SUMMARY



EDITH GREEN - WENDELL WYATT FEDERAL BUILDING


photo by Sara Tepfer

PROJECT DETAILS

LOCATION:	Portland, Oregon
COMPLETION DATE:	May, 2013
SQUARE FOOTAGE:	525,421 sf
PROGRAM:	federal offices
DELIVERY METHOD:	IPD
TOTAL COST:	$120 million
EUI:	28 kBtu/sf [predicted]
AWARDS + RATINGS:	tracking LEED Platinum 2030-compliant

BACKGROUND

The Edith Green – Wendell Wyatt [EGWW] federal building modernization included both core/shell and tenant improvements. SERA Architects was hired in 2003 for the design-bid-build project; however, in 2007, the EGWW project was not approved for funding and was subsequently shelved.

The project was revisited in 2009 under the American Recovery and Reinvestment Act [ARRA]. The original designs had to be completely re-scoped, as projects approved by ARRA must achieve federally defined High Performance Green Building requirements. To further challenge the project team, ARRA set a September 2010 deadline to establish a GMP. The team determined that the only conceivable way to achieve these ambitious sustainability goals in such a short timeframe was through a streamlined delivery process. The team decided to implement IPD through a modified CM/GC contract structure.

CLEARLY DEFINED PROJECT GOALS

The time and performance constraints established by the ARRA funding requirements provided clearly defined project goals around which team members could quickly align.

BACKGROUND [continued]

The team conducted a three-month energy analysis of the existing building to understand what was needed to achieve the project's performance goals. Prior to contractor selection, the team held a two-day High Performance Building Workshop to understand these goals. Attendees included GSA representatives, the A/E team, and any interested contractors. A testament to the interest in and impact of the project, all twelve of the invited contractors participated in the workshop, without compensation.

To collectively achieve the project goals, the team developed a separate CM+6 document, which outlined specific collaborative strategies that would be implemented on the project. These included onsite owner management, early involvement of first-tier subcontractors, integrated document development, colocation, and optimized use of BIM.

NOTABLE ENERGY PERFORMANCE STRATEGIES

The team employed several strategies to maintain compliance with ARRA requirements and to achieve high-priority building performance goals.

COLLECTIVE JUDGEMENT

"We had a design aesthetic that we were trying to achieve, but it had to be informed by energy conservation, and both were limited by the amount of money," describes Patrick Brunner of the US GSA. Striking a cost-effective balance among the three required continuous input from the design team, the building science consultants for performance implications, and the supplier for manufacturing limitations. The result was, among other energy conservation measures, a cost-optimized, iconic shading system that enhances building performance and communicates the sustainability goals of the project.

Project participants' collective expertise was used to develop a weighting scheme to evaluate major interior systems. Representatives from each of the key stakeholders met to determine selection criteria [first cost, O/M cost, and energy performance] and appropriate weights to optimize the systems for both cost and energy. Including the supplier in these conversations resulted in additional unexpected value, as was noted by Lisa Petterson of SERA Architects. "The façade manufacturers became equal partners at the table," she explained. The manufacturers explained the production limitations, and the group collectively determined a way to streamline the process to suit those constraints.

METRICS-BASED DECISION MAKING

The owner established an expectation for lifecycle cost analysis for all energy performance recommendations; this required consistent energy model verification. The A/E team met with the energy analyst on a monthly basis to validate design decisions with energy model outputs. Any proposed changes to construction were first evaluated for their impacts on energy.

By contract, contractors were required to attend bi-weekly review meetings focusing on

NOTABLE ENERGY PERFORMANCE STRATEGIES [continued]

constructability reviews, resolving constructability issues, ongoing value engineering, and LEED certification assistance.

COST AND RISK MANAGEMENT STRATEGIES

STRUCTURED LEADERSHIP

GSA Region 10 has been experimenting with integrated leadership structures since 2002. After each project, they have assessed perception of team integration, transparency of communication, and other process metrics. GSA Region 10 has found that continuous, aggressive owner engagement with the project team is among the most effective approaches. As a result, they developed a leadership structure for the EGWW project that maximized owner engagement with the project team: The owner became the project champion, followed by the core team, which met several times per week and consisted of high-level project managers from the architect, owner, and contractor. Project managers then distributed information to other members of the integrated team.

The integrated structure ensured continuous involvement from preliminary design to project handoff and maintained high levels of team cohesion and mutual trust and respect. Contractors did not fear desertion during the construction phase, and the A/E team trusted and valued contractors' expertise during planning and design.

CLEAR METRICS AND CONTINUOUS FEEDBACK

Process performance metrics were established early in the delivery process, including schedule, cost, constructability, document accuracy, and rework reduction. Teams would be evaluated quarterly using federally established reporting criteria. In addition to these formal reports, portions of each weekly meeting were devoted to providing informal process performance feedback and discussing opportunities for improvement. The constant feedback established a team commitment to continuous improvement and proactive problem solving. Gradually, this additional feedback enabled the team to proactively respond to the owner's needs.

CO-LOCATION

Two owner representatives, the A/E design team, the prime management team and their first-tier subcontractors all co-located full-time to a shared office space on the project site. The owner and contractor both acknowledged the benefits of co-location, describing its ability to ease orientation and integration to the project and to simplify communication between project participants. BIM, coupled with co-location, allowed day-to-day issues to be resolved in minutes rather than hours or days and reduced the number of project change orders. The owner noted that co-location should not start until the core team has already developed a foundational relationship.

BENEFITS OF AN INTEGRATED APPROACH

EGWW PERFORMANCE

The benefits of the integrated approach on process performance were clear, as the team was able to achieve its scheduling and sustainability goals through successful implementation of a more efficient delivery strategy. Additionally, the team was able to generate enough unspent contingency funds to provide post-construction, contractor-led training sessions with facilities managers. As well as easing the transition from contractor to facilities manager, this training phase supplemented commissioning work, revealing additional operations problems, which could then be quickly resolved before the building was fully occupied.

MARKET PARADIGM SHIFT

The EGWW project inspired company-level changes for both Howard S. Wright and SERA Architects. Prior to the project, HSW was not well-versed about high-performance projects; however, since the project, there has been a stronger commitment to pursuing green projects and to providing staff with the necessary resources and knowledge for sustainable design and construction. "The project has become truly transformational within our company," describes Matthew Braun of HSW. In addition to this, both SERA and Balfour Beatty, of which HSW is a part, have developed resources specifically for IPD. Through education and the development of in-house IPD tools, each firm is committed to demonstrating to clients that the IPD approach is in the owner's best interest.

LESSONS LEARNED

OWNER INVOLVEMENT

All interview participants acknowledged the benefit and necessity of high levels of owner engagement. The owner expressed the importance of both clear, quickly established expectations and continuous, candid evaluation. The owner found that fostering open communication did not mean that team members were constantly trying to please one another; rather, the goal was to focus on understanding the problems to be solved and the most practical approaches to solving them using the given strengths of the team. In this scenario, the owner served as the integrator, facilitating interaction and engagement. "It takes a lot of work at the beginning to build the foundational relationships," describes Brunner. "If it's not a shared sacrifice, there is no shared benefit."

"GO SLOW TO GO FAST"

The EGWW project team relied on an intensified early planning approach which the group called, "go slow to go fast." The expanded planning phase was used to rigorously evaluate energy and water strategies through daylighting studies, energy studies, and

LESSONS LEARNED [continued]

façade analysis and to establish mutual trust and respect among team members. The group also spent time each week to understand, evaluate, and re-evaluate team priorities. The result was a well-aligned, motivated team that was well-prepared for efficient design development and construction phases.

WHY NOT TRUE IPD?

The owner expressed the necessity to re-define IPD beyond the contract structure. "What's important is the ability to work as, and within, a team format," said Patrick Brunner of GSA. Though the contract structure helps, similar results can be achieved through a GMP contract with both incentive and award fees and a collective discussion as to what subcontracts are needed and how best to solicit, manage, and incentivize them.

RESOURCES

IPD case study: Cheng, R., Dale, K., Aspenson, A., & Salmela, K. (2012). IPD Case Studies. Duluth, Minnesota: American Institute of Architects.

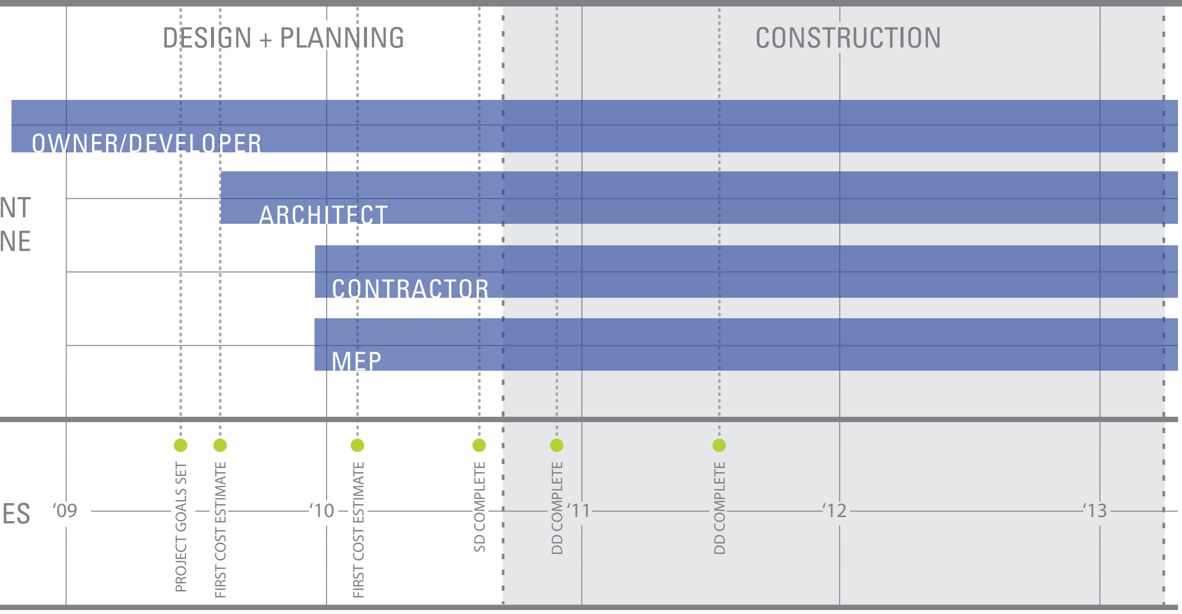
Architect:	Lisa Petterson, SERA Architects
	Jim Riley, SERA Architects
Contractor:	Matthew Braun, Howard S. Wright
Owner representative:	Patrick Brunner, US GSA

EDITH GREEN - WENDELL WYATT FEDERAL BUILDING

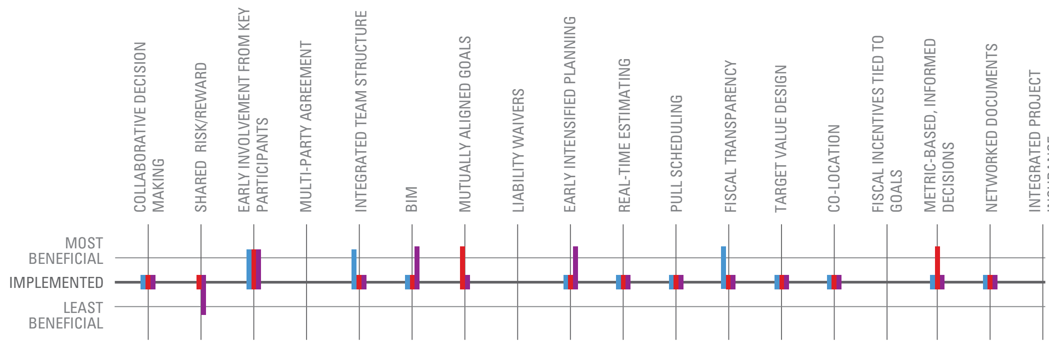
SUMMARY

INVOLVEMENT TIMELINE

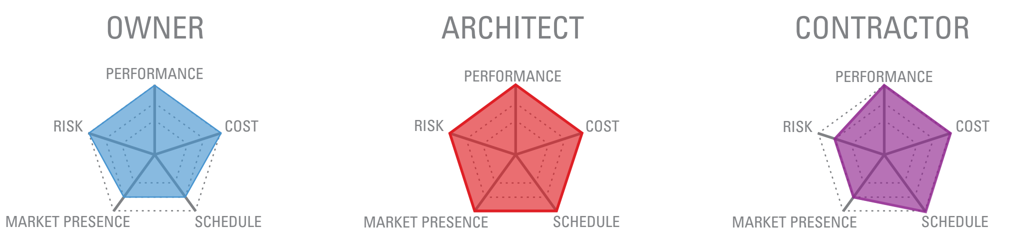
PROJECT MILESTONES



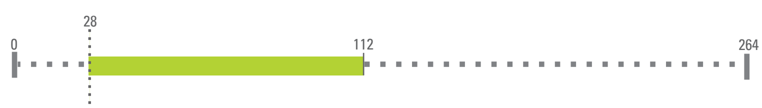
PROJECT DELIVERY IMPLEMENTATION STRATEGIES



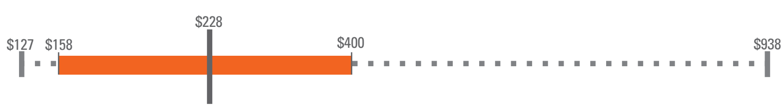
PERCEIVED BENEFITS OF PROJECT DELIVERY IMPLEMENTATION STRATEGIES



EUI [kBtu/ft² yr]



COST PER SQUARE-FOOT [$/ft²]



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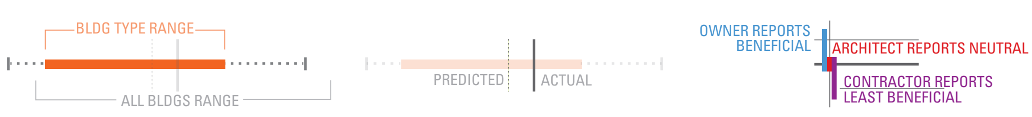

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PERFORMANCE METRICS FOR NEXT GENERATION GREEN BUILDINGS

Metric		Summary
2030 Challenge for Buildings	**Overview**	A performance-based energy standard requiring increasingly stringent energy performance for al new construction and major renovations. There are no requirements for water, materials, site, or health considerations.
	Energy	Achieve 60% energy reduction from regional average or median type-specific baseline. Energy reduction goals are tiered: 75% by 2015; 80% by 2020; 90% by 2025; 100% by 2030.
	More info	http://architecture2030.org/2030_challenge/the_2030_challenge
ILFI Living Building Challenge	**Overview**	A performance-based standard requiring typology-specific targets defined within seven performance areas [petals]. Petals are each subdivided into a total of 20 imperatives. While the strategies to achieve these imperatives will vary across different project types, the fundamental considerations remain mostly the same.
	Energy	100% of the energy needs must be supplied by onsite renewable energy on a net annual basis
	Water	100% of water must be supplied by rainwater capture or other closed loop systems; no chemical filtration systems; 100% of storm water and discharge must be managed on site
	Materials	No red-listed chemicals may be used on site, and materials must be regionally sourced; projects must purchase carbon offsets equivalent to the embodied energy of the project.
	Site	Projects are limited to greyfield or brownfield sites and must integrate agricultural opportunities, habitat exchange, minimal site paving, and site awareness [avoiding adjacent shadow-casting].
	Health	Total VOC concentration and respirable suspended particles must be measured nine months post-occupancy.
	Other	The project must encourage the use of public transportation, bikes and walking, be ADA compliant, and seamlessly integrate biophilia and beauty.
	More info	http://living-future.org/living-building-challenge/certification/certification-options
ILFI Petal Recognition	**Overview**	Slightly less demanding than the Living Building Challenge, a project must satisfy at least the requirements of three or more petals, one of which must be the energy, water, or materials petal. See above for a summary of petal requirements.
ILFI Net Zero Energy Certification	**Overview**	A performance-based energy standard requiring 100% of the energy needs to be supplied by onsite renewable energy on a net annual basis. The project must also achieve the site and systems integration requirements of a Living Building.
	Energy	The project must achieve net zero energy and verify that the building is operating as claimed.
	Site	The project must be built on either a greyfield or brownfield site, and the building cannot excessively shade adjacent buildings.
	Other	The project must educate and inspire occupants and demonstrate that renewables can be beautifully integrated into the building's design.
Net zero site energy	**Energy**	A performance-based standard requiring annual **site** energy use to be offset by onsite renewable energy generation [Torcellini, et al. 2007].
Net zero source energy	**Energy**	A performance-based standard requiring annual **primary energy** use to be offset by onsite renewable energy generation. Net zero source energy accounts for transmission losses [Torcellini, et al. 2007].
Net zero energy costs	**Energy**	A performance-based standard requiring utility credits to offset utility bills on an annual basis [Torcellini, et al. 2007].
Net zero energy capable	**Energy**	A performance-based standard requiring a total EUI of 35 kBtu/sf/yr, at maximum. Net zero feasibility does, in practice, depend on other factors including space availability for PV, climate, and money [NBI 2012].

PERFORMANCE METRICS FOR NEXT GENERATION GREEN BUILDINGS [continued]

Metric		Summary
LEED v2.2 Gold or Higher	**Overview**	A prescriptive standard, details depend on rating system [construction- and usage-specific]; across all rating systems, projects must earn points in six categories [SS, WE, MR, EA, EQ, RP] and may earn additional ID points. except for LEED for Homes, Platinum certification requires 80+ points earned; Gold certification requires 60-79 points earned.
	Energy	Points are earned based on predicted performance improvement from code-minimum baseline building; commissioning, measurement and verification, refrigerant management, and the project's integration of onsite renewables
	Water	Points are earned based on water use reduction [performance incentive] and the project's integration of water-efficient landscaping and innovative waste water technologies.
	Materials	Points are earned based on a project's commitment to: building reuse and construction waste management; materials reuse, recycled, rapidly renewable, third-party certified, regionally sourced materials; onsite recycling.
	Site	A project earns points by encourging alternative transportation, brownfield redevelopment, density and connectivity and by reducing heat island effect, light pollution, erosion, and stormwater runoff.
	Health	A project earns points from measured IAQ performance, outdoor air delivery monitoring, and construction IAQ management, by using low-VOC adhesives and finishes, and by providing systems controllability, thermal comfort, daylighting, and views
	Other	Projects earn additional points from innovation in design and regionally-specific credit incentives.
	More info	http://www.usgbc.org/leed
AIA/COTE Top Ten	**Overview**	A green building design competition in which built work is examined using ten sustainable design metrics including performance, site/context sensitivity, materials use, and project longevity/adaptability.
	Energy	Projects are evaluated for energy use reduction, systems integration, onsite renewable and/or alternative energy generation, peak demand reduction, and passive survivability.
	Water	Projects are evaluated for water conservation, onsite recycling, and rainwater capture measures.
	Materials	Winning projects evaluate materials' lifecycle health/environmental impacts and encourage occupancy waste reduction.
	Site	Projects are evaluated for their ability to respond to ecological context, wildlife/habitat preservation, and their response to local density/ site conditions [infill, greyfield, brownfield, etc.].
	Other	Projects are evaluated for their bioclimatic design, adaptability, community integration, project right-sizing, and efficient program organization.
	More Info	http://www2.aiatopten.org/hpb/grid2011.cfm?project_id=0&section=2

APPENDIX 2

INTERVIEW QUESTIONS

The following questions were asked of interview participants. Not all questions were asked of each participant. Questions were selected based on the expertise of the interviewee and the availability of existing published information about the project.

- Who was involved in the initial goal setting and pre-design phases?
- When were the sustainablity goals established? Who was involved?
- At what times did the different project team members join the team?
- How much upfront planning was required prior to assembling the project team?
- How much owner involvement was required once the team was assembled?
- How were you involved in the design process?
- How were the contracts established?
- How frequently did the team meet?
- How was the team structured?
- How was decision-making handled?
- How and when did you establish metrics for team success and evaluation?
- How did you handle cost estimating in this project?
- To what extent were commissioning and aftercare included in the budget?
- To what extent did collaborative project delivery extend into the operations and management phases?
- Achieivng more ambitious energy performance goals may require higher levels of innovation, which is one of the reasons IPD approaches seem well-suited for high-performance projects. How did the team balance innovation and risk in this project?
- Did you and/or your firm have prior experience with the delivery method implemented in this project?
- To what extent was BIM used on this project? How was it integrated with the cost and energy models, if at all?
- How did the project delivery method and strategies used for this project differ from past projects, if at all?
- If it was, in what ways was the design process for this project different from others that you've worked on [of similar complexity]?
- How were energy goals, scope, and cost balanced? How were tradeoffs evaluated?
- If you've worked on a true IPD project, how did it compare to this one?
- What was the level of engagement between engineer and architect? Architect and owner? Architect and user? Engineer and user?
- What do you see as barriers to true IPD uptake?

PARTICIPANT SURVEY

The following set of questions was sent to interview participants. It was less of a survey and more of an online form used to collect information that would be quite tedious to gather over the phone. The average response time was about ten minutes for completion. The survey is shown below in word format; the online format can be accessed here: <http://ucbpsych.qualtrics.com/SE/?SID=SV_2ctVr86Vmhsye5n>.

Project Delivery Methods Survey [page 1 of 4]

Q1 Project name

Q2 Who did you work for?
- ❑ Architect
- ❑ Contractor
- ❑ Owner
- ❑ MEP
- ❑ Energy Analyst
- ❑ Sustainability Consultant
- ❑ Other

Q3 What was your role?

Project Delivery and Methods Survey [page 2 of 4]

Q4 Which of the following project delivery methods did this project use?
- ❍ Design/Bid/Build
- ❍ Design/Build
- ❍ CM/GC
- ❍ CM at risk
- ❍ Integrated Project Delivery
- ❍ Other

Q5 Who do you consider part of the project's "core team"? Check all that apply.
- ❑ Architect
- ❑ Contractor
- ❑ Owner
- ❑ MEP
- ❑ Energy Analyst
- ❑ Sustainability Consultant
- ❑ Other

PARTICIPANT SURVEY [continued]

Q6 Please fill in the matrix below, which asks about specific strategies that were used to implement the project delivery method reported above. Please choose a maximum of three strategies each for the second two columns.

	Implemented in this project [check all that apply]	Three most important for successful delivery [check three maximum]	Three least important for successful delivery [check three maximum]
Early, intensified planning/team building	❑	❑	❑
Early involvement of core team members	❑	❑	❑
Collaborative decision making	❑	❑	❑
Mutually aligned/defined goals	❑	❑	❑
Integrated team structure	❑	❑	❑
Co-location of core team	❑	❑	❑
Pull scheduling	❑	❑	❑
Metric-based, informed decisions	❑	❑	❑
Real-time estimating	❑	❑	❑
Target Value Design	❑	❑	❑
BIM	❑	❑	❑
Networked documents/communication	❑	❑	❑
Multiple party contract or single purpose entity	❑	❑	❑
Liability waivers	❑	❑	❑
Integrated project insurance	❑	❑	❑
Shared risk/reward	❑	❑	❑
Fiscal incentives tied to goals	❑	❑	❑
Fiscal transparency	❑	❑	❑

PARTICIPANT SURVEY [continued]

Project Delivery and Methods Survey [page 3 of 4]

Q7 How did the implemented strategies benefit the following factors, if at all? A score of zero indicates that the implemented strategies were completely unhelpful, while a score of 3 indicates that they were very helpful.

0 1 2 3 Cost predictability - extent to which the process methodology improved cost predictability.

0 1 2 3 Schedule predictability - extent to which the process methodology improved schedule predictability.

0 1 2 3 Risk management - extent to which the process methodology benefitted risk management for the project.

0 1 2 3 Firm's market presence - extent to which the process provided valuable lessons learned and marketable experience for future projects.

0 1 2 3 Building performance [energy, water use, etc.] - extent to which the process enabled the project to meet its sustainability targets.

0 1 2 3 Overall goals - extent to which the process contributed to the achievement of the project's overall goals.

Project Delivery and Methods Survey [page 4 of 4]

Q8 Approximately when [month/year] were the following goals and milestones established/achieved for the project?

- Overall project goals established
- First cost estimate
- Pre-design phase ends
- Schematic design phase ends
- Design development phase ends
- Construction documents phase ends
- Construction phase starts
- Occupancy phase starts
- Living Building Certification
- LEED certification
- Net-zero energy verification
- Post-occupancy evaluation