# SUSTAINABLE DESIGN IN PROJECT DELIVERY: A DISCUSSION ON CURRENT AND FUTURE TRENDS

Karno Widjaja[1]

## INTRODUCTION

Sustainability principles have become an integral part of the design and construction process for many new construction projects. The selection of the project delivery method (PDM) is extremely important in the effective execution of the project, and plays a critical role in establishing communication and coordination between the key entities: owner, architect, and contractor.

The goal of this paper is to hopefully serve as a starting point for further discussion to improve on the AEC industry's current integration of sustainability principles in PDMs. The first step consists of an assessment of current project delivery systems from a sustainable design perspective. This is followed by a determination of the current limitations, and examination of the various disruptions in the industry. Various literature sources are analyzed to form a framework to discuss improvements and optimization strategies beyond the current system. Thereafter, proposed solutions are introduced at both stakeholders, as well as PDM scales.

In this paper, the focus for the conducted analysis and proposed methodologies is predicated on new construction projects instead of retrofits due to the resources available. However, the principles can similarly be applied to retrofit scenarios as well, depending on the specific requirements of the individual project at play.

**KEYWORDS:**

sustainable design, project delivery method, prioritization of sustainable strategies, energy performance contracting, energy service companies

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## DEFINING SUSTAINABLE DESIGN

Sustainable design can be defined as an approach whereby the needs of the present are met without compromising the ability of future generations to meet their own needs (United Nations, 1987). Within the realm of the built environment and the involvement of architects, the advent of technology in the 20th century resulted in a loss of sustainability principles in the design of new architecture. The building professions lagged in placing an importance on

1. Karno Widjaja, Harvard Graduate School of Design, Cambridge, MA, USA, kwidjaja@gsd.harvard.edu

the impact of sustainability until the energy crisis of the 1970s, with incremental progress made between then and now. Key advancements include the establishment of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System by the US Green Building Council (USGBC) in 1993, as well as more recent approaches such as the Architecture 2030 challenge that has been endorsed by The American Institute of Architects (AIA), and the Living Building Challenge.

In addition to traditional building design concerns such as economy, utility, durability, and aesthetics, sustainability oriented developments are required to consider additional principles in the design process. The overall strategies in terms of green design underlines additional concerns which should be considered in the execution of projects given specific constraints (Kubba, 2012):

- Ensure maximum overall energy efficiency
- Conserve nonrenewable energy and scarce materials
- Encourage the use of renewable energy and materials that are sustainably harvested
- Optimize site selection to conserve green space and minimize transportation impacts
- Minimize the ecological impact of energy and materials used
- Orient buildings to take maximum advantage of sunlight and microclimate
- Ensure that water use is efficient, and minimize wastewater and runoff
- Minimize human exposure to hazardous materials
- Conserve and restore local air, water soils, flora, and fauna
- Minimize adverse impacts of materials by employing green products

The prioritization of these strategies is also crucial in the consideration of sustainable buildings; there is a multiplier effect associated with the order in which these strategies affect resource/energy consumption parameters. Author Graham Farmer cites a design centric definition of sustainable design in his article:

> "a type of increasingly globalized cultural production in which experts (engineers, architects, [… etc.]) design artifacts (based on formal knowledge), to be constructed by a second party (a contractor or manufacturer) at a distant locale (using the most efficient technology available), and purchased by yet a third party (a customer or consumer). The chain of production involves significant and social distancing between the designer, the builder, and the ultimate inhabitant."

He continues to build upon the theoretical framework mentioned above, terming a definition he calls "de-contextualized practice," which reflects the most recognized current professional practice strategy in the Architecture, Engineering, and Construction (AEC) industry:

> "the prevalent, policy-oriented interpretation of sustainability that tends to situate environmental issues within a context which is distant in terms of space and time … emphasis on the functional constitution of technology and tends to separate buildings, materials or related practices from their particular contexts of realization and operation." (Farmer, 2013)

The prioritization of sustainability strategies is an important component of the design and construction process. One such example is the Primer on Sustainable Building published by the Green Development Services (GDS) arm of the Rocky Mountain Institute (RMI), with the goal to "enable architects, developers, and other real estate professions to integrate

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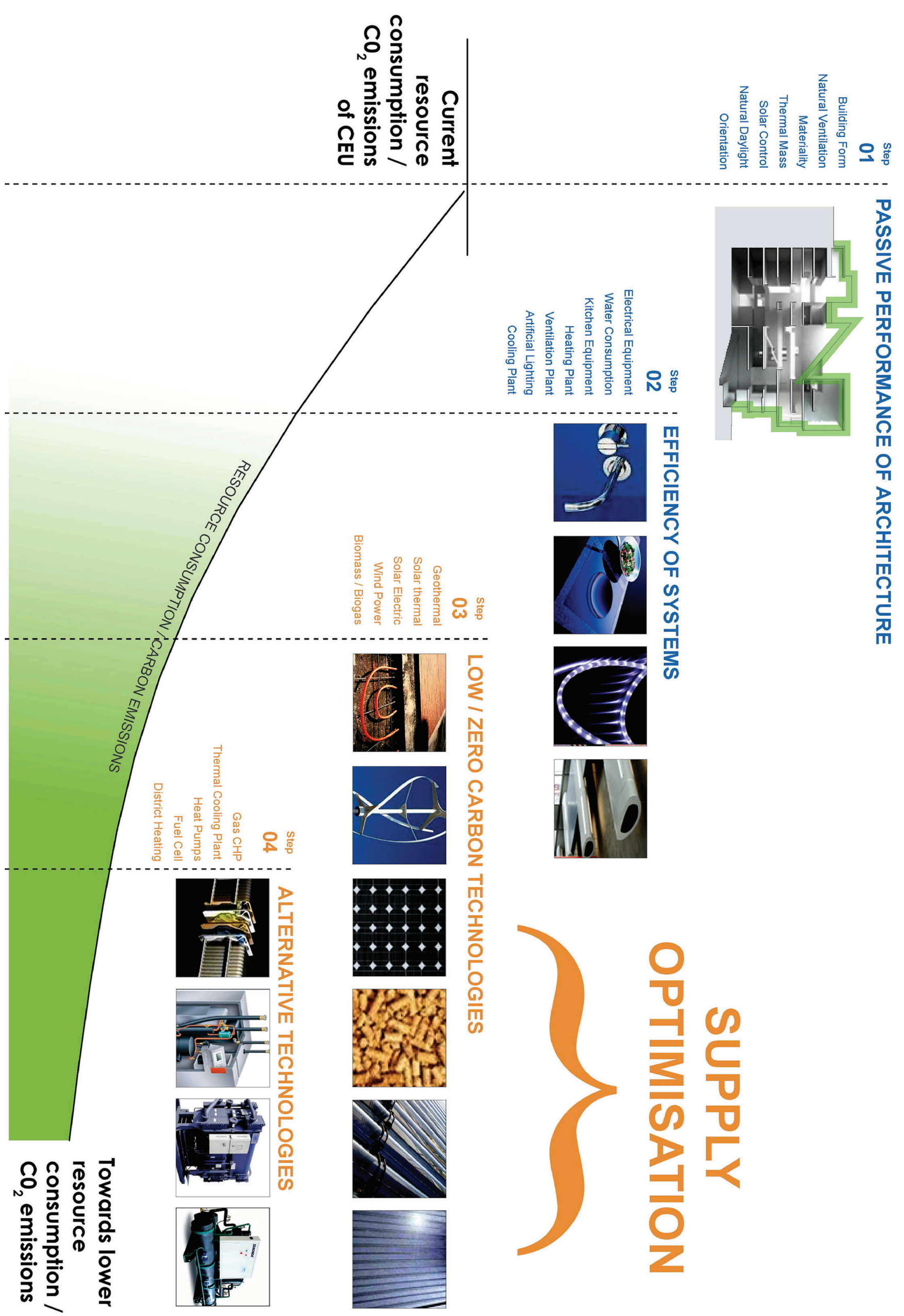
**FIGURE 1:** Sustainability strategies prioritization diagram (Central European University, 2015).

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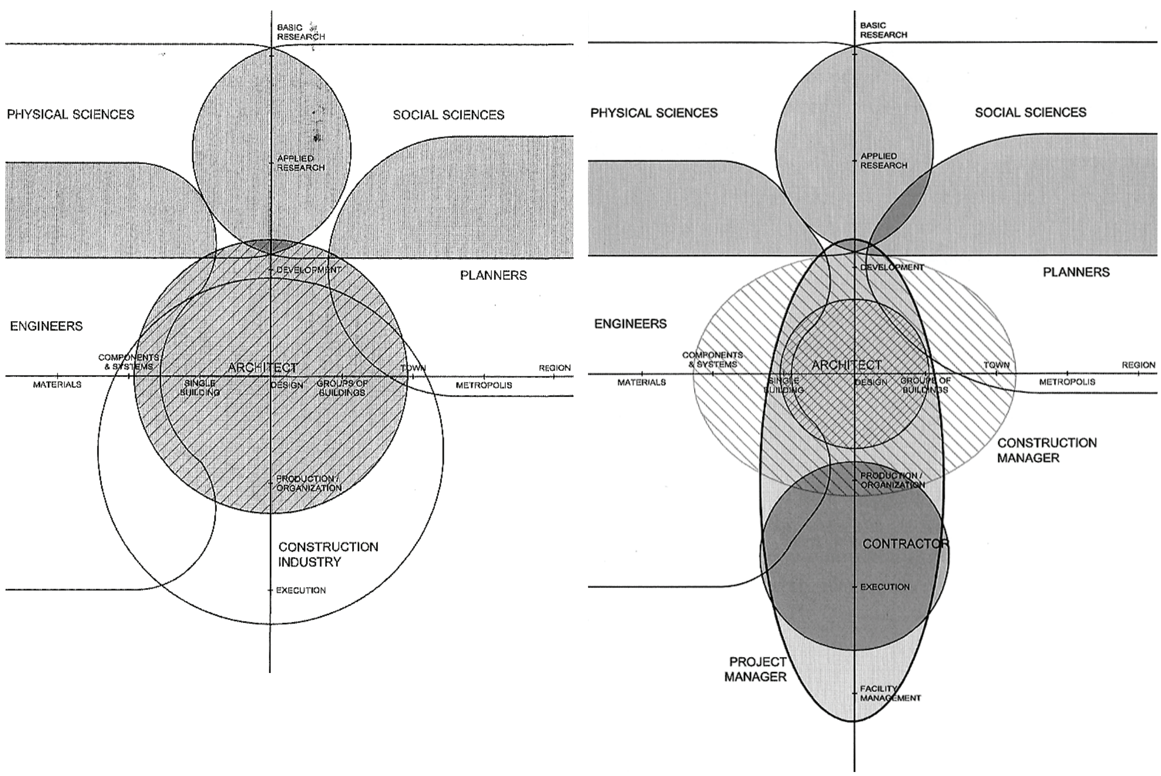
energy-efficient and environmentally responsive design into specific projects." (Barnett & Browning, 2007) The primer methodically describes the process by which sustainable building principles are executed, with similarities to the steps outlined in Figure 1.

- Site Selection
- Site Development
- Transportation
- Building Placement
- Land Design
- Building Configuration
- The Building Shell
- Energy Use Inside
- Saving Water
- Building Ecology
- Operations
- Specification and Construction

## STAKEHOLDERS INVOLVED

There are numerous stakeholders invested in the pursuit of these strategies, the primary entities being the owner, contractor, and architect. Their relationships depend on the PDM contracted by the parties involved. In his book *Down Detour Road: An Architect in Search of Practice*, author Eric Cesal references the diagram illustrating the architect's relationship to surrounding professions by Richard Llewelyn-Davies (1967), and adds his own interpretation

**FIGURE 2:** Richard Llewelyn-Davis (left), Eric Cesal's interpretation (right).



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of how this sphere of influence has shrunk, and in some cases, been relegated in today's settings (Cesal, 2010). This is shown below in Figure 2.

The current dilemma seems to extend beyond just the architect, but to the value of the entire AEC industry as a whole, which is primarily responsible for shaping the future of our built environment. Given the scope of the interconnected system, this paper focuses on the relationship between the architect and the sustainability related consultants in the architect/design lead team setting. These consultant entities typically include the following:

- Sustainability Consultant
- LEED Consultant
- Energy Modeler
- Commissioning Agent (CA)
- Energy Service Companies (ESCOs) (typically for retrofits versus new construction)
- Utility Service Entities (typically for retrofits versus new construction)

ESCOs are defined as "a business that develops, installs, and arranges financing for projects designed to improve the energy efficiency and maintenance costs for facilities over a seven to twenty-year time period … act as project developers … assume the technical and performance risk associated with the project." (Clinton Foundation, 2009)

## ENERGY PERFORMANCE CONTRACTING (EPC)

Energy Performance Contracting (EPC) is a means of improving energy efficiency in new building projects using an innovative contracting mechanism. While the specifics are related to the type of project delivery method selected for the project, it is typically set in motion by the owner who initiates a performance contract relationship to provide an incentive to the architect/engineer (A/E) to design an energy-efficient building. Alternatively, the owner might also turn to ESCOs to provide a turnkey service, particularly for retrofit projects, making the ESCO the party responsible for designing, implementing, and measuring the results of an EPC project (Clinton Foundation, 2009). The investment in energy efficiency consists of additional professional services for design, energy analysis, building commissioning.

The benefits of energy performance contracting are traditionally reaped by the owner, which include reduced energy bills and lower operating cost, increased value to tenant from improved lighting and HVAC commanding a higher rent, and a marketing advantage with a green image. With the ESCO taking on project performance risks, the owner is able to avoid a potential insufficient minimum required return on capital from the generated resource savings of energy and water conservation measures (Clinton Foundation, 2009).

The downsides include a possible increase in first costs to pay for energy efficiency measures, and increased management duties to oversee energy efficiency work (Eubank & William, 2004). Also, it might not be prudent to use EPC or an ESCO if the owner entity has adequate in-house engineering expertise, knowledge of the latest technologies, and access to capital to implement and finance their own projects (Clinton Foundation, 2009). While this scenario typically applies to retrofit projects, there are instances where an owner such as an institution or university would stipulate requirements to contracted AEC entities for new construction projects. An example of this is the Harvard Green Building Standards, which applies to all capital projects and has to be included in all Requests for Proposals issued for new projects and referenced in contracts for design consultants and construction managers.

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These procedures have helped to establish Harvard as an internationally recognized leader in green building and are an essential component of the University's commitment to sustainability (Harvard Office for Sustainability, 2016).

## EXISTING PROJECT DELIVERY METHODS (PDMS)

The workflow and processes involved in each PDM is described to give context to the limitations of the existing framework, and subsequently focuses on the involvement of EPC, as well as the extent of sustainable design principles and processes involved.

### *Traditional Green Design-Bid-Build (DBB)*

The traditional design-bid-build (DBB) project delivery system remains the most widely used today, and has been the approach of choice for both public and private construction projects. The owner typically hires an architect/engineer (A/E) team to prepare a complete set of plans and specifications, followed by a bidding process to select a contractor based on lowest cost. In this system, the owner, architect, and contractor have a triangular arrangement, although there is no direct legal contract existing between the architect and contractor (Eley Associates, 2004).

The advantages of this arrangement include the ability to provide much needed checks and balances between the design and construction phases of the project, and allows the owner to provide significant input into the process throughout the project design's phase. This is crucial from a sustainability perspective, especially if the owner desires the implementation and is willing to invest in a green building. However, there are several drawbacks to this project delivery method, a non-productive adversarial relationship might develop between the architect and contractor as the individual entities resort to protecting their respective interests. Furthermore, there is the possibility of extended schedules often caused by long procurement processes. The greatest disadvantage of DBB is the dependency of the budget, schedule, and success of the project on the completeness of the contract documents (Bilec & Ries, 2006).

In terms of EPC, the contract is negotiated between the owner and the A/E team. In order to accept responsibility for the energy performance of the building, the A/E scope of services is expanded to include a greater role in energy analysis, construction administration, and building commissioning. The shortfall of this model lies in the A/E's limited ability to control construction quality or improve the design during construction; this also applies to aspects relating to sustainability performance. This results in the owner's recognition that a design which performs well in a computer model is not guaranteed to perform as well in reality, affecting the trade-off between risk mitigation and the incentive structure for an EPC in this PDM.

### *Green Construction Management (CM)*

According to the ASHRAE *Green Guide*, "The construction manager (CM) method is the process undertaken by public and private owners in which a firm with extensive experience in construction management and general contracting is hired during the design phase to assess project capital costs and constructability issues." The CM can be an agent of the owner, with the responsibility of managing both the design and construction stages of the project (Eley Associates, 2004), similarly to the DB PDM to be explained in the next section.

There are advantages of the at-risk CM model pertaining to sustainable performance. In terms of collaboration, the architect and contractor working together during the design

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portion can result in clarity of the prioritization of sustainability measures, reducing the probability of any unexpected costs increments after the GMP is established. This is important as HVAC and building enclosure components form a sizable amount of the total building construction budget. From the owner's perspective, the benefit is a contractor perspective in making decisions on the trade-offs during the design phase between cost, quality, and construction duration. All these variables would allow for the prioritization of sustainability strategies into the construction phase as well. This is also coupled with the expertise of the construction manager in pre-qualifying trade contractors that might have better performance and workmanship e.g. a sub-contractor responsible for envelope insulation installation. Disadvantages of the CM PDM includes the number of stakeholders involved in resolving potential disputes and disagreements of legitimate project scope modifications that may or may not have an impact on the GMP, as well as the nature of the CM. This might also affect its ability to coordinate effectively and protect the owner's interests (Bilec & Ries, 2006).

Within the EPC realm, it is assumed that the CM is financially responsible for the project, manages the design, construction, and commissioning. The architects, engineers, consultants, and contractors have contracts with only the CM, and not the owner. It is therefore natural for the owner to make the EPC with the CM, it is then up to the CM to make an additional performance contract with the A/E if that is desired. The performance target is specified for the whole building, which gives the CM the flexibility to achieve the required energy savings using any means. Rather than choosing energy units, dollar values are usually considered, and savings may come from cuts in utility energy, demand reductions, load shifting, predictions or control. This continues through the design evaluation period through to the performance verification stage of the project. A typical final evaluation is done at the end of the second year of operation. The performance target is adjusted for factors that are not within the control of the CM entity at the time of design e.g. operating schedules, equipment loads, predicted versus actual weather conditions etc.

The limitation of this PDM lies in the performance structure not necessarily disseminating to entities such as the architect and its consultants who are involved from the early design stages of the building where sustainability concerns have the largest impact on overall performance (refer to Figure 1). This is the case since the CM may choose not to have a contract with the A/E entity with no incentive for performance. Furthermore, the conclusion of the contract at the end of the performance verification does not take the building's performance over its operation life-cycle into account.

### *Green Design-Build (DB)*

One of the distinguishing features of the design-build (DB) approach is that the owner contracts with one entity (the design/builder) that assumes responsibility for the entire project: its design, supervision, construction, and final delivery.

Although there are benefits to using this project delivery method from a traditional building design perspective, such as fewer change orders and reduced risk to the owner, the success in terms of implementing the project from a sustainability performance perspective lies with the intent of the owner without input from other involved stakeholders (similar to DBB). The potential disadvantages of this model include loss of control of project design, less project oversight/control of quality, as well as a lack of consideration for the operations stage of the building post-construction. An example is the scenario in which the A/E entity is no longer the owner's independent consultant, but a part of the design-build contractor. This is

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the case with most DB firms or joint ventures being spearheaded by the contractor, possibly due to a bonding capacity which architecture firms are not able to match, with the latter as a sub consultant. This might result in a situation where the architect's recommendations are given lower priority due to budget constraints (Bilec & Ries, 2006).

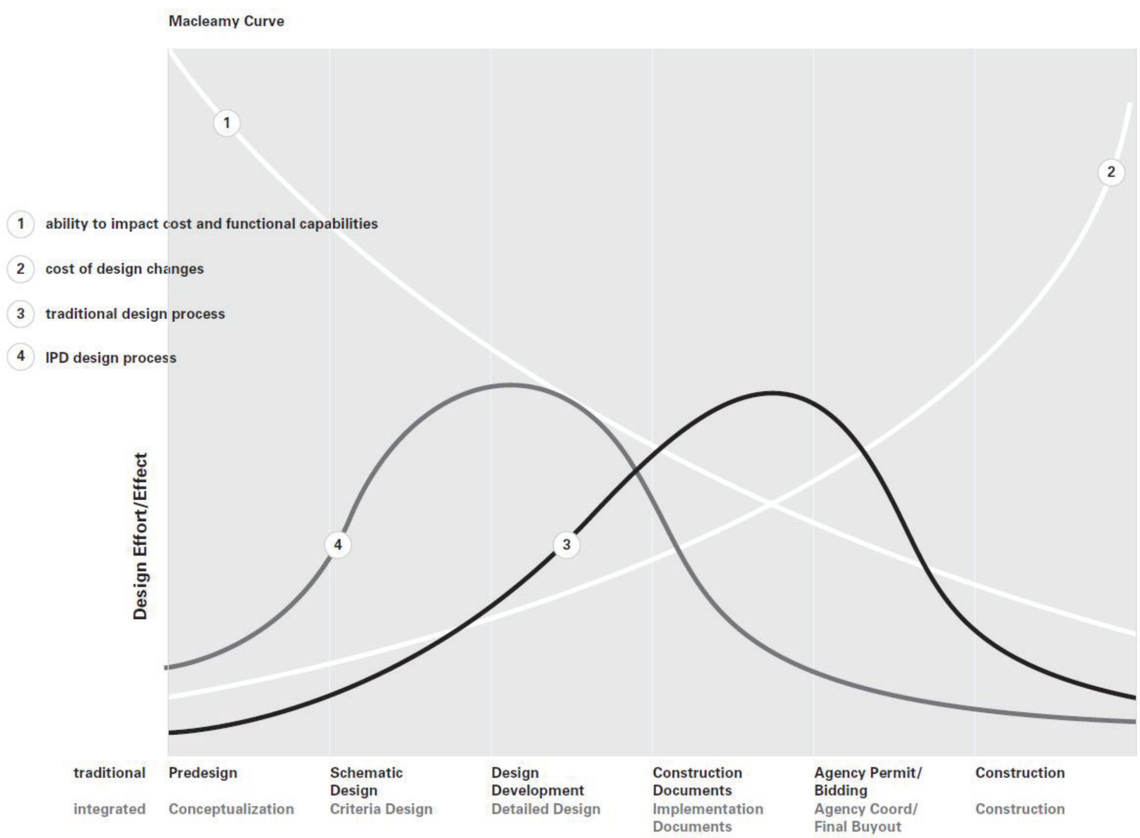
From an EPC perspective, the problems faced are similar to the CM model. The difference lies in the owner setting up an EPC with the DB entity instead.

### *Integrated Project Delivery (IPD)*

According to the AIA guide on Integrated Project Delivery (IPD), it is "a project delivery approach that integrates, people, systems, business structures and practices into a process that collaboratively harnesses the talent and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction." (The American Institute of Architects, 2007) IPD is a highly collaborative process that integrates the expertise of project teams from the early stages of the project onwards, experts from every discipline are present at the project's inception to ensure that decisions meet the needs of all involved entities (Ghassemi & Becerik-Gerber, 2011) This is shown diagrammatically in Figure 3.

The advantage of this PDM in terms of sustainable design is that all parties are involved collaboratively in the outcome. The highest and best sustainable results in meeting energy goals are best achieved through collaborative processes. Although some energy reductions are achievable through current prescriptive means (such as the ASHRAE Advanced Energy

**FIGURE 3:** "MacLeamy Curve" (The American Institute of Architects, 2007).



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Design Guides of 30% & 50% (ASHRAE, 2015)), interactions that are encouraged in the IPD framework could lead to greater reductions. However, even with the support of several professional organizations such as the AIA, as well as the demonstration of various research on its benefits and challenges, the number of project using IPD remains relatively small, with its infancy period lasting longer than expected (Ghassemi & Becerik-Gerber, 2011).

In terms of EPC within the IPD context, the compensation framework would depend on the specific form of contractual agreement being adopted (Project Alliance, Single Purpose Entities, or Relational Contracts) For example, there is the ability to adopt incentives for non-owner participants like the A/E entity to benefit from, such as a gain share bonus for exceeding project targets in the sustainability category.

## LIMITATIONS OF EXISTING PDMS

In considering the workflow processes of existing PDMs, there are several interrelated problems that pose a challenge to the achievement of project sustainability goals. Firstly, concerns over liability and risk tend to increase design and construction expenses due to the extra paperwork required by all the participating entities; this results in difficulty implementing out-of-the-box design thinking and innovation. Secondly, the oversizing of equipment for minimizing liability and reduction of expenses leads to a lack of attention placed on energy efficiency, especially as designers' fees are not dependent on this metric (with the exceptions of EPCs). Thirdly, the linear sequence of traditional design processes coupled with construction shortcuts reduces the potential for design integration and innovation. Furthermore, efficient and sustainable products are substituted in order to ensure on-time execution of work. Lastly and most importantly, the lack of a whole-systems design view results in missed opportunities to identify design synergies that might optimize multifarious design and construction concerns (Bendewald, 2013).

There has been work done to address the limitations of existing PDMs, an example being 7group's guide on Integrative Design. It describes in detail a practical, replicable Integrative Design Process (IDP), going through the concepts and philosophy of whole-systems thinking, subsequently including a manual-based section with process outlines, practical examples, case studies, and stories from their own design experiences to delineate the fundamental aspects of this process (7group and Bill Reed, 2009). A diagram of the comparison between an example integrative and traditional processes is shown in Figure 4.

Although some attention has been placed on the post-occupancy phase, it usually ends within a few years of project completion. This is also the case with the existing IDP framework in which "as-built" conditions are handed off to the owner for long term building management, maintenance, and operations. There would still probably exist between the various entities, a mentality of "value-engineering" within the project involvement time period even with the pain-gain scenario. This could be in order to secure the necessary compensation, while lacking longer term considerations such as the project's life cycle performance etc.

AIA Document D503: Guide for Sustainable Projects describes the release of "sustainable projects" (SP) versions of key AIA Contract Documents, incorporating the model language developed for SP into the Conventional (A201) family, while maintaining underlying contractual relationships of language of the core agreement. SP additions are also made to AIA Document B214: Architect's Services: LEED Certification. However, the guide does not endorse any specific PDMs as the most appropriate for sustainable building projects, instead proposing the SP addendum to existing PDMs (The American Institute of Architects, 2013).



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**FIGURE 4:** Integrative and Traditional Process Outlines (7group and Bill Reed, 2009).

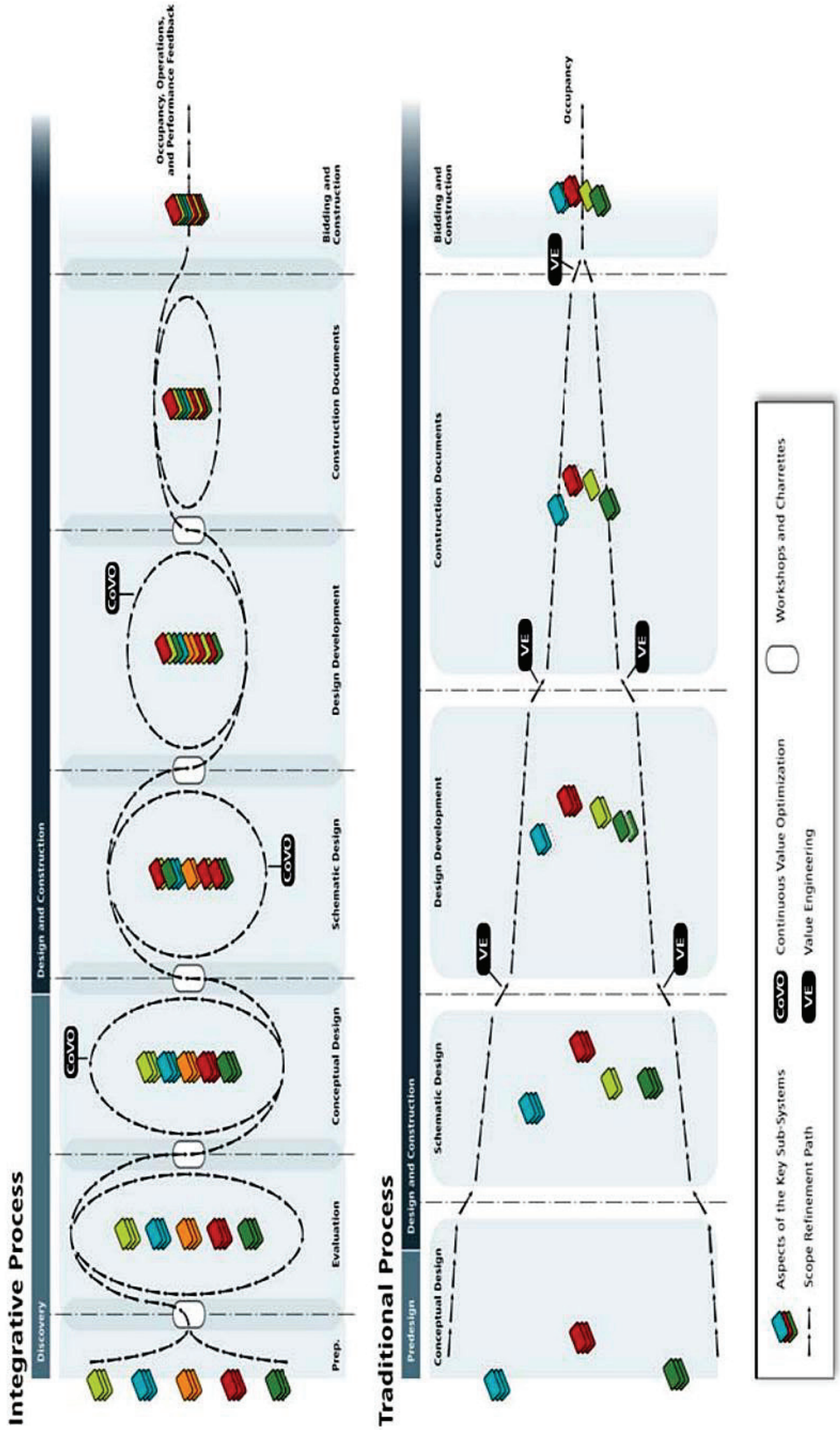




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**FIGURE 5:** Broad Energy Modeling Goals and Benefits (The American Institute of Architects, 2012).

**Broad Energy Modeling Goals and Benefits**

| | CONCEPT DESIGN | SCHEMATIC DESIGN | DESIGN DEVELOPMENT | CONSTRUCTION DOCUMENTS | CONSTRUCTION/ POST-OCCUPANCY |
|---|---|---|---|---|---|
| TEAM GOALS | Use early Design Performance Modeling to help define the goals of the project<br>(NOTE: Design Performance modeling could be with either component modeling tools or a basic building energy model, but should at this stage address other performance parameters in addition to energy.)<br>Define the project requirements, as informed by modeling results | Review financial and performance energy information from model to guide design decisions | Review design alternatives based on initial goals, as informed by modeling results<br>Create baseline and alternatives to choose from | Create documentation needed to accompany energy model results for code compliance<br>Create documentation needed to accompany energy model results for commissioning and metering/ monitoring validation | Use results of the as-built model for commissioning<br>Compare results of the as-built model against metered data to look for operating problems |
| ENERGY MODELING GOALS | Experiment with building siting and orientation<br>Determine effective envelope constructions<br>Assess the effects of daylighting and other passive strategies<br>Explore ways to reduce loads | Create a rough baseline energy model<br>Test energy efficiency measures to determine the lowest possible energy use<br>Set up thermal zones and HVAC options | Create proposed models with system alternatives to choose from<br>Refine, add detail, and modify the models, as needed<br>Provide annual energy use charts and other performance metrics for baseline vs proposed<br>Evaluate specific products for project<br>Test control strategies<br>Do quality control check on the models | Complete the final design model<br>Do quality control check on the models<br>Create final results documentation needed to submit for code compliance | Complete the as-built model with installed component cut-sheet performance values<br>Collect metered operating data to create a calibrated model to share with outcome-based database |
| BENEFITS TO CLIENT | Get entire design team united around project goals<br>Use modeling results to make design decisions informed by integrated system performance | Test different options before implementing them<br>Determine the most efficient and cost effective solutions | Determine the most efficient and cost effective solutions<br>Size mechanical equipment correctly | Use energy model as part of LEED or other sustainable design certification application<br>Provide ability to better predict energy use in the building | Provide ability to refine operations to meet reduced energy use goals in the built project |

The AIA has also released a set of guidelines that discusses the goals and benefits of integrating energy modeling into the design process. However, the responsibilities of sustainable design, commissioning, LEED goals, and energy modeling, are still traditionally handled by different consultant entities throughout various stages of the design and construction process. This is also evident from the EPC drawbacks with the A/E entity take responsibility for the management and performance of all the above entities.

There have been existing proposals such as hybrid A/E practices that capitalize on the limitations (Yudelson, 2009). For example, some architects have decided that the best way to deliver integrated design while avoiding the contractual and logistical challenges is to have an integrated design team within the same office. There appears to be a trend amongst a few firms to bring the key AEC stakeholders under one roof. An example of this is a large firm such as AECOM. However, the limitation of this approach is the cost involved in employment, there are a large number of small and medium sized offices that do not have the necessary resources to take such a course of action. This is seen in the reliance on various sustainability affiliated consultants for various projects if the office does not have its own in-house team. The availability of these resources is also dependent on the available budget for the project, which does not constituent a large number of ongoing new construction. Another factor is its inability to provide services that would ensure the project's performance from a sustainability perspective between conceptualization and into operations.

## PROPOSED METHODOLOGIES

### *Current Research & Basis for Reinvention*

Author Chrissna du Plessis writes in her article about the need to reinvent the AEC industry, with two pressing concerns that relates to the need for reinventing the existing PDMs. There is a need to accommodate and regulate a new layer of built environment professionals, as well as the redesign of professional fee structures that move beyond the current practice that is based on a percentage of project capital costs (Plessis, 2014). This is in contrast to research focusing on the changing of construction processes (Klotz, Horman, & Bodenschatz, A Lean Modeling Protocol for Evaluating Green Project Delivery, 2007) (Klotz, Process Transparency for Sustainable Building Delivery, 2009). In the energy design realm, there has been literature on its emergence as a new expertise as assisted by building simulation. Increasingly specific guidelines on the use of building simulation has been proposed to work in tandem with various stages of the design process by means of a recipe approach (Ferrero, Lenta, Monetti, Fabrizio, & Filippi, 2015). Figure 6 shows the energy design steps during the main stages of the design process.

Another example of advances being made in the sustainability delivery realm is a study conducted that aims to understand the interactions between architects and engineers on a sample project using a developed workflow map. This process focuses on the BIM-energy modeling process, taking a slightly different approach as compared to the previous example. The ultimate goal is to help owners make decisions and project managers better understand opportunities for improvement, exposing potential misalignment of information and expectations between the two entities that can cause project schedule and implementation delays (Grinberg & Rendek, 2013). Figure 7 below shows the workflow map for a sample commercial retrofit project's schematic design (SD) phase.



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**FIGURE 6:** Energy design steps during integrated design process (Ferrero, Lenta, Monetti, Fabrizio, & Filippi, 2015).

| ENERGY DESIGN | INTEGRATED DESIGN | | | | | | |
|---|---|---|---|---|---|---|---|
| | CONCEPT DESIGN | | | SCHEMATIC DESIGN | | DEVELOPEMENT DESIGN | CONSTRUCTION DOCUMENT |
| DESIGN SOLUTION | *Step 1*<br>• Identification energy goals;<br>• Identification energy strategies;<br>• Site analysis;<br>• Climatic analysis;<br>• Available energy sources analysis;<br>• Building functional requirement analysis; | *Step 2*<br>• Compare with "reference building models" to evaluate energy goals and strategies; | *Step 3*<br>• Building volume and form design;<br>• Building energy systems studies: (thermal generating unit) definition according to energy sources (step1). Concept of DHW production and PV; | *Step 4*<br>• Envelope design (walls and windows);<br>• Solar shading design;<br>• Natural ventilation system definition; | *Step 5*<br>• HVAC system design according to envelope needs and thermal generating unit (step3);<br>• DHV production system design;<br>• PV system design; | *Step 6*<br>• Design solutions and control schedule optimization<br>• Prove concept design energy goal compliance; | *Step 7*<br>• Prove regional energy code compliance;<br>• Prove Rating system compliance; |
| SIMULATION MODEL | *Step 1*<br>• Consult weather data (Climate consultant, weather tool); | *Step 2*<br>• Input data collection from "reference buildings"; | *Step 3*<br>• Building orientation simulation;<br>• Building volume and form simulation;<br>• Simulation to define heated and unheated zones; | *Step 4*<br>• Simulation to define window to wall ratio;<br>• Simulation to define opaque envelope stratigraphy;<br>• Simulation to define glazing surface<br>• Simulation to evaluate solar shading solution;<br>• Natural ventilation simulation; | *Step 5*<br>• HVAC system sizing simulation;<br>• Simulation to contrasting different kind of HVAC systems;<br>• DHW production system and PV system modelling or according input data from another model; | *Step 6*<br>• HVAC system optimization simulation;<br>• imulation to optimize use and control schedule of: air-conditioning, lighting, (input data from lighting simulation), ventilation, solar shading;<br>• Simulation to optimize DHW production system and PV system; | *Step 7*<br>• Baseline building creation and compare with design solution; |

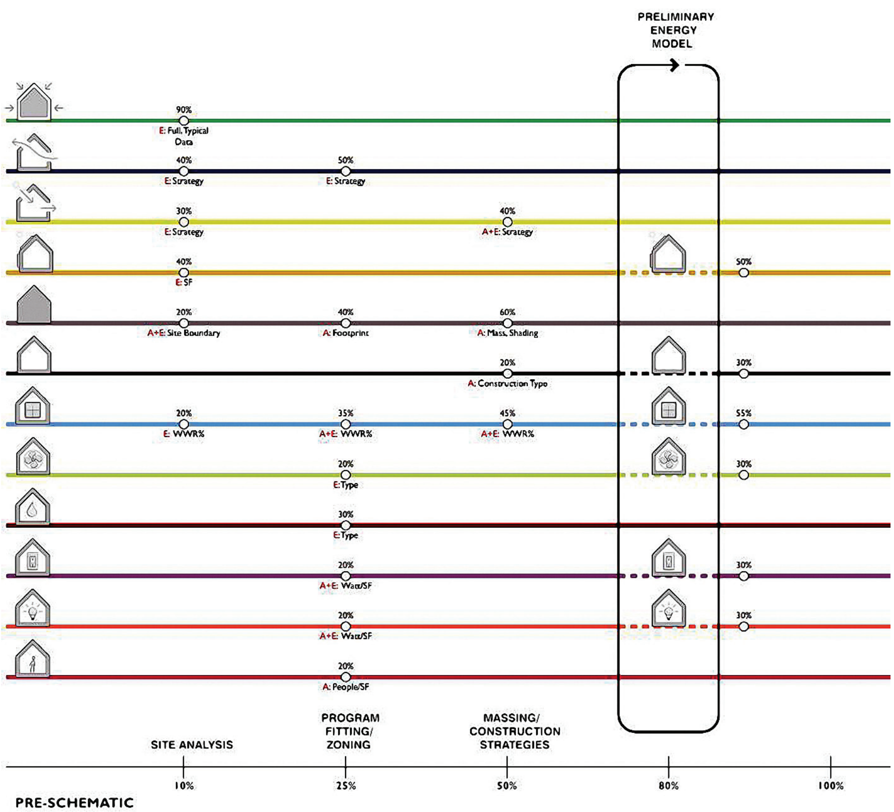


**FIGURE 7:** Information sharing workflow map for BIM-energy modeling process (Grinberg & Rendek, 2013).

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From the above cases, although there has been research conducted on the optimization of existing PDMs via various approaches and workflows, there has been less attention paid to potential reorganization and reinvention of the entities involved, or a restructured PDM that extends beyond the current contractural lifecycle of the design project. The next section of the paper attempts to discuss two potential methodologies that could pave the way for future changes in the AEC industry in the area of sustainable design.

### *A New Sustainability Entity*

In order to connect the various entities that serve the sustainability goals of the project throughout the design and construction process, one of the proposed steps is the creation of a unified entity to replace the roles currently served by sustainability consultants, commissioning agents, energy modelers, LEED consultants, and ESCOs. While larger corporations in the AEC industry have the resources to integrate such an entity to serve their project needs, several other organizations have been formed to serve these roles in a consultancy capacity to architecture and engineering firms that do not have such capabilities. A prominent example of this would be the environmental design consultants and building services engineering firm Atelier Ten. Their services can be further divided into the absorption of traditional consultant roles, as well as additional value-added services shown below (Atelier Ten, 2015).

Traditional roles:

- Environmental Design (part of sustainability consultant role)
- MEP Engineering (traditionally consultant to architect's team)
- Energy Analysis (Energy modeler role)
- Lighting Design (traditionally consultant to architect's team)
- Master planning (traditionally consultant to architect's team)
- Benchmarking (part of sustainability consultant role)
- Carbon management (part of sustainability consultant role)
- Fire Engineering (traditionally consultant to architect's team)

Value-added services:

- Healthy Building: Integrated with the more conventional sustainability consultant services
- Verification: Similar to, but does not cover the full scope of conventional commissioning services, or the financial agreements provided by an ESCO
- Incentives and Funding: Organization helps clients i.e. building owners determine eligibility for energy and sustainability incentive programs, but does not finance the energy measures like an ESCO

Although the services offered by Atelier Ten are diverse and have contributed towards many sustainably high performing projects, it should be noted that the extent of its coverage within the project delivery process is primarily within the design phases (concept, schematic, and design development), or in conducting Post Occupancy Evaluations (POEs) in the immediate period after a design project is completed. The justification for a unified entity that covers the post design phases has been described in a recent study. The paper mentions that "creating a model that would eventually be used for commissioning and operations could be

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a new business opportunity if one could overcome certain barriers." (Samuelson, Lantz, & Reinhart, 2011) The identified barriers are as follows:

- The issue of "Human Interoperability", or the ability of the future user to understand the original author's work
- Intellectual Property Rights: confusion over model ownership
- Trade Secrets: the fear of existing expert modelers losing their competitive edge if beginners gain access to their tools and techniques
- Liability: fear of being held accountable for changes made to the model by others or for decisions made based on the model outside of its original intent

Most, if not all of the above mentioned barriers can be overcome with the proposed unified entity. The contractual and liability issues will be dealt in the accompanying proposed PDM that will be discussed in the next section of this paper. Advances in data capture and analysis tool can help bridge this process. Design and building simulation models have traditionally needed independent geometric and performance specification profiles to be built in customized computer models before the simulation could be completed, the recent interoperability of software packages has allowed for BIM models to support building performance simulation directly (Lesniewski & Berkebile, 2013).

### *Integrated Project Delivery (IPD) + Operate Project Delivery Method (PDM)*

An alternate proposal concurrent with the sustainable entity is the expansion of the current IPD framework past the existing closeout stage, with the intention of bridging the current gap between building design and operations into the longer term. The contractual relationship of the multi-party agreement between the design, builder, and owner entities could take the form of a Single Purpose Entity (SPE). Under the existing IPD framework, a SPE is a temporary, but formal legal structure that is created to realize a specific project. The key participants have an equity interest in the SPE based on their individual skill, creativity, experience, services, access to capital or financial contribution. These equity owners are paid for any services they provide to the SPE, an additional element of compensation is tied to overall project success (The American Institute of Architects, 2007).

It is proposed that the SPE continue into the operations segment of the building's life cycle. In order to deal with the potential change in equity owners, the existing project closure compensation system could be tired to non-owner participants who no longer need to be involved with the SPE. Alternatively, this would also allow for a scenario where the new sustainability entity could become an equity owner and reap from the performance compensation structure in the operations phase. This is assuming that the SPE does own the project. If the SPE is instead formed solely to facilitate the design and construction of the project in a fully integrated manner, there would probably need to be an establishment of a new, independent legal entity for the operational life cycle phase.

For example, the design and builder entities could choose to pull out of the SPE at the end of project close out and the fulfillment of their obligations. In this model, the new sustainability entity would have served the role as a consultant under the design and / or owner depending on the specific project. This entity could inherit the "as-built" conditions for long term building management, maintenance, and operations, in collaboration with the owner in the reformed SPE.



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### *Challenges*

Major challenges to the implementation of these proposals would be finance and legal barriers. Finance barriers refer to the challenges of selecting compensation and incentive structures that are commensurate to the unique characteristics of the project and its respective stakeholders (Cohen, 2010). Legal barriers refer to issues of liability and insurance.

In terms of the former, a potential area of contention between the proposed sustainability entity / IDP + Operate and the other stakeholders in the design project would be the method of compensation. Based on current research, most existing IDP projects follow a guaranteed maximum price (GMP) or estimated maximum price (EMP) model for the compensation of their projects, with limitations to its effectiveness if the owner needs financing in order to obtain funding and bond the project. Within this concept of risk and reward, the different approaches of sharing risk and reward are also debatable in terms of its relative effectiveness: sharing cost savings and overruns, and profit pooling (Ghassemi & Becerik-Gerber, 2011).

In terms of the latter, current insurance products are designed to assign liability to each stakeholder in the design project. Research conducted has shown that multi-party agreement projects were able to overcome the legal barriers by selecting projects that fit within traditional insurance products or were able to purchase a variant that met the needs of the design project (Ghassemi & Becerik-Gerber, 2011).While this might not be as prevalent an issue with the proposed sustainability entity as it is anticipated that it might be able to negotiate a consultant – architect contract, there are potential complications with the IDP + Operate proposal. An area of complication would be potential issues with the independent legal entity that all stakeholders need to be a part of.

## DISCUSSION & CONCLUSION

It is hoped that the strategies discussed above will allow for sustainability centric projects to be implemented on a wider scale and quantity. A subsequent step would be to test the effectiveness of the recommended proposals on a hypothetical scenario. However, the current nature of complex projects with various contractual arrangements between numerous entities makes it difficult for integrated design to occur. This is the case when there are too many architects, contractors, and engineers responsible for various critical and interactive components that affect the sustainability performance of a design project. In this case, a best attempt would be to identify entities that are considered the primarily delivers of meeting sustainability goals (Eley Associates, 2004). In addition, a clearly defined business model and the potential profitability of the unified sustainability entity will have to be assessed. In terms of the proposed project delivery method, the legal issues surrounding the continuity of the SPE would have to be further analyzed.

This paper provided an examination of the variety of existing PDMs and processes currently in use in the AEC industry for the design and construction of sustainable projects, and analyzed its limitations in its effectiveness in the continued emphasis of sustainability principles from the conceptual through to the operational stages of project delivery. New methodologies such as the introduction of a new sustainability entity, and the extension of the IPD framework into the operational stage of a project for improving the current situation were introduced and discussed. However, additional research and hypothesis testing is required to determine the effectiveness of these new strategies. Furthermore, it is difficult to assess this in a theoretical setting with the increasingly complex nature of speculative buildings and the number of stakeholders involved.

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## ACKNOWLEDGEMENTS
The author would like to thank Mark R. Johnson for his suggestions, advice, and comments on approaches for writing this paper.

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