

## The Consortium for Building Energy Innovation

CBEI is focused on generating impact in the small- and medium-sized commercial building (SMSCB) retrofit market. CBEI is comprised of 14 organizations including major research universities, global industrial firms, and national laboratories from across the United States who collaborate to develop and demonstrate solutions for 50% energy reduction in existing buildings by 2030. The CBEI *FINDINGS* series highlights important and actionable technical, application, operation and policy research results that will accelerate energy efficiency retrofits when applied by various market participants. CBEI views these *FINDINGS* as a portal for stakeholders to access resources and/or expertise to implement change.

## Integrative Design Process

The integrative design and delivery process includes establishing a new and different governance structure to guide a retrofit construction project, and a collaborative team that works together to make decisions for the design of the buildings. Conventional building design usually involves a series of hand-offs from owner to architect, from builder to occupant. This path does not invite all affected parties into the planning process, and therefore does not take into account their needs, areas of expertise or insights. In some cases, using the conventional method, incompatible elements of the design are not discovered until late in the process when it is expensive to make changes. In contrast, the integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion.

Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall project objectives. In addition to extensive collaboration, integrative design involves a “whole building design” approach. A building is viewed as an interdependent system, as opposed to an accumulation of its separate components (site, structure, systems and use). The goal of looking at all the systems together to make sure they work in harmony rather than against each other.

CBEI facilitated meetings of building stakeholders – including owner, occupant, architect, construction management, and contractor representatives – to collectively identify project values in a pre-design workshop. Project values for the building were determined to include collaboration, learning, performance, predictability, and certainty, among others. Successive decisions were made using the filter of the accepted project values. This process was designed to increase quality and efficiency, decrease waste, and foster greater collaboration among stakeholders.

## Research Finding: Building 661 Integrative Design Process (IDP)

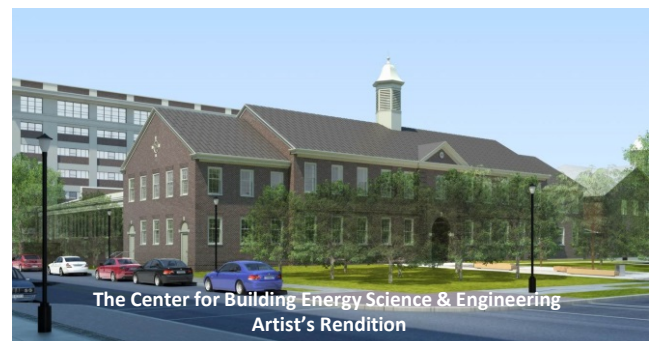
Portions of the Integrative Design worked well during the Building 661 deep retrofit.

Project Values Development was an essential tool in delivering the final product.

The Integrative Design Process was not successful in reducing the number of change orders expected.

The Collaborative Addendum driven by the IDP largely fell apart when the first major construction problem surfaced.

IDP is recognized as a valuable tool to deliver superior building renovations, but does not appear to be adaptable to the multi-prime project delivery vehicle.



### Pennsylvania Separations Act

Pennsylvania is one of only three states to require public construction projects to be based on “multi-prime contracting”.

The multiple prime project delivery system requires public entities to hold and manage multiple prime contracts, making the public entity responsible for the coordination of those contracts. As a result, the public entity increases its contractual liability exposure and is forced to be involved in contractual disputes, project delay claims by contractors, and the project’s day-to-day budget, schedule, and scope.

In 1913 it was a simple task to isolate the general construction, mechanical, electrical and plumbing issues from one another. Today code changes and technology have complicated the isolation of trades. When design professionals develop a set of contract documents for a building it is developed as one integrated and unified document. Under the Separations Act this unified document is then broken into at least four pieces for bidding purposes and the contractors are asked to put it all back together without coordination problems between the trades. As well intentioned and thorough as the documentation is to distinguish the division of those pieces, “gray zones” frequently arise as items of financial contention. This method unquestionably opens the door for change orders that are unnecessary.

### Building 661 Planning Process

The Center for Building Energy Science (aka Building 661) deep retrofit project was funded with State of Pennsylvania money requiring multi-prime bidding. Working with the architect, an integrative design and project delivery process was created to develop plans specifications using a whole building design approach and including expertise from all construction elements. It should be noted that the participating entities could not bid on the project because of their participation in the design process.

The Hypothesis being tested throughout the retrofit of Building 661 is:

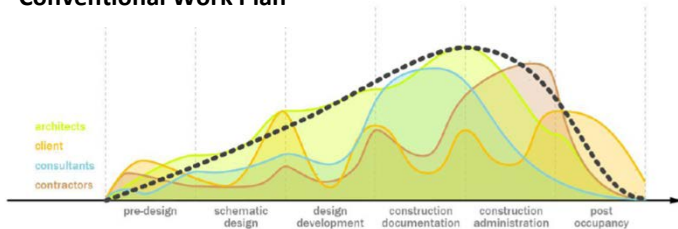
*The Integrative Design Process will significantly improve the design and deep retrofit process delivering a superior product at reduced cost over conventional practice for public buildings under multi-prime contracting conditions.*

This deep retrofit was designed as a research project to test the hypotheses and measure the results.

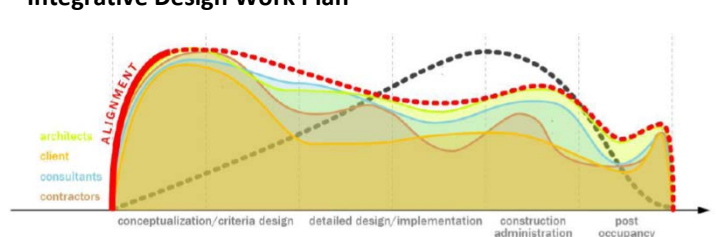
The resulting conceptual work flow plans for conventional design practice and integrative design practice are shown below.

Expending collaborative work effort in the early stages of a project’s design, should lead to reduced effort during construction.

Conventional Work Plan

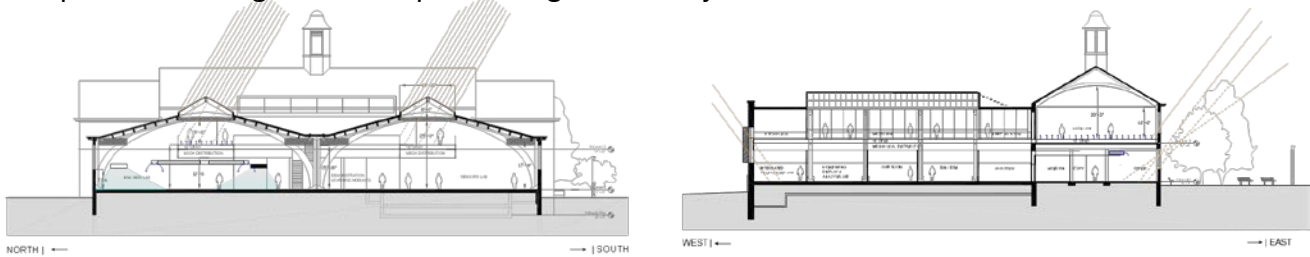


Integrative Design Work Plan



## Building 661 Specifications, Bidding, and Construction

The design and construction documents included a 16 page COLLABORATION ADDENDUM, V6.0 (CA V6) which memorialized the Integrative Design Intent of the parties as follows: “The likelihood of a successful project will be increased by promoting the following objectives: all members of the Project Team collaborating throughout design and construction with all other members of the Project Team; planning and managing the Project as a network of commitments; optimizing the Project as a whole, rather than any particular piece; and tightly coupling learning with action to promote continuous improvement throughout the life of the Project. By forming a collaborative Project Team, the parties intend to gain the benefit of an open and creative learning environment, where members are encouraged to share ideas freely in an atmosphere of mutual respect and tolerance. Project Team members shall work together and individually to achieve transparent and cooperative exchange of information in all matters relating to the Project and to share ideas for improving project delivery. Team members shall actively promote harmony, collaboration and cooperation among all entities performing on the Project.”



The commitment of the design team to developing a project design that met the building’s intended values was very evident and successful. This occurred because of the dedication of all parties including the owner, architect, consulting engineer, costing and project management company, as well as, the compensated design contractors including structural, mechanical, electrical and plumbing. The final design and specifications in the bid package reflected the Integrative Design Process in delivering a superior design.

The CA V6 contained the following statement emphasizing the fact that collaboration was an intention and was not legally binding. “The stated objectives of this Addendum notwithstanding, nothing contained herein shall be construed to create a separate contractual relationship between any of the parties, to render any party to this Addendum responsible for the contractual obligations of any other party or to make any party a third party beneficiary of any other party’s contract with the Owner.”

The multi-prime awards were executed with the lowest acceptable bidders and the project commenced. The first major test of this new collaborative approach surfaced when it was discovered that the pre-case concrete roofing panels had slid and some were crushed. It was determined that some of the metal support angles fasteners had failed (pictured below right). Instead of collaboration, the construction “team” fell back into their respective roles of protecting their position.

During the course of this deep retrofit there were some collaborative successes, but looking back on the project from one important metric, change orders, one cannot find a substantial difference. The project has processed about 100 change orders, including the usual few from the owner, which is typical for a multi-prime project like this one. The end product will undoubtedly meet the CBEI’s requirements, but the multi-prime integrated design process, in this case, was not completely successful.



## Lessons Learned

1. Developing well defined project values and using them to consistently make design choices provides a solid platform for creating the final design and during the construction.
2. Involving contractors, who are not involved in the construction, can be helpful in avoiding some issues, but this did not achieve a reduction in change orders. The additional issue is that these participants were compensated and they also were excluded from the bidding process.
3. Working under the multi-prime business model, collaborative intent does not appear to work during the construction phase. Two contributing elements are 1) changing business culture is a difficult process, and 2) multi-prime low bidding requires very little contingency to use in collaboratively solving problems.

## Moving Forward

The Integrative Design Process has been proven effective in large building energy retrofits. CBEI believe that certain elements of the IDP are valuable to be implemented in small and medium sized buildings.

Building 661 revealed that well defined project values define the project desired outcomes. This process developed the right bid package. Deep building retrofits, like building 661, are often faced with significant unknown issues like the roof panel fastener failure.

The well-defined project values enabled the project team to “edit” the project to find money without jeopardizing valuable outcomes. The key is to balance the cost of generating the project values.

An integrated design team involving contractors on a multi-prime contract ultimately was not completely successful as these entities were precluded from bidding on the project. This concept should not be considered replicable.

CBEI’s experience suggests that the multi-prime bidding process is not conducive to integrative design. The question is what to do about it.

One answer might be found in the neighboring state of Ohio, which in 2011, revised its century old multi-prime public project requirement by adding three additional contracting options for public buildings. In addition to multi-prime contracting, Ohio now permits: 1) retention of a general contractor based on sealed bid solicitations, 2) design-build contracting based on requests for proposals and “best value” selection processes; and 3) “at risk” construction manager procurements based on requests for proposals and “best value” selection processes where the basis of compensation is the cost of the work with a guaranteed maximum price. Allows for open book Guaranteed Maximum Price, design-assist, and subcontractor prequalification within design build and “at risk” construction manager delivery methods. It seems logical and worthwhile to extend these tools used in the private sector to the public sector in Pennsylvania. Nevertheless, this requires legislation to revise the current multi-prime public project requirement.

Until the multi-prime law changes, CBEI recommends adding a definitive change order management system for all prime contractors requiring open-book reporting. This contract requirement will provide transparent financial tracking of all changes made to a project which should improve integrative design practice under multi-prime contracting scenarios.

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CBEI is a research and demonstration center that works in close partnership with DOE's Building Technologies Office.

### Acknowledgment:

"This material is based upon work supported by the Consortium for Building Energy Innovation (CBEI) sponsored by the U.S. Department of Energy under Award Number DE-EE0004261."

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