Deploying and Testing Integrated Design Roadmaps for Advanced Energy Retrofits

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ABSTRACT

This paper details the deployment of the *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* for the energy efficient renovation of small to medium-sized commercial buildings in the United States. The ID process discussed in this paper was developed as part of a suite of market targeted process documents and is the result of research sponsored by the United States (US) Department of Energy at the CBEI – Consortium for Building Energy Innovation (formerly the Energy Efficient Buildings Hub), since 2012. The three-tiered document suite instructs and empowers owners, project managers, financial investors, architecture, engineering and construction professionals, as well as energy modeling and measurement consultants with information on the value of ID in the process of completing an AER.

This paper offers a detailed description of the *ID AER Roadmap Project Team Guide* intended for use by professionals in the advanced energy retrofit field. More broadly, the *ID AER Roadmap* document suite includes an *Overview* brochure that introduces ID concepts, as well as a *Reference Manual* that details these concepts. The third part of the suite of documents is the *Project Team Guide*, which is the particular focus of this paper. It outlines the recommended ID process for all contracted participants of an AER and helps said participants identify the shared priorities and goals of value to all team members. The *Project Team Guide* is structured into five distinct phases with each phase further defined by a Resource Gathering (RG) stage and/or a Collaborative Meeting (CM) stage.

Additionally, this paper introduces a coordinated initiative to test and verify the process protocols developed in the *Project Team Guide*. By way of five AER demonstration projects, also funded by the US Department of Energy, the *ID AER Roadmap* is being challenged and revised in the market. These projects involve the participation of public and private building owners, who range from large municipalities to small non-profits, and they represent a variety of building uses including institutional, commercial, and transportation. The scope of retrofit work for each project includes a building envelope and systems based renovation focused on achieving maximum energy saving. Typical energy conservation measures being considered include the replacement of heating and lighting systems, and the introduction of controls and sensors.

These demonstration projects test and verify the structure of the protocols defined in the *ID AER Roadmap* including the proposed timeline of activities in each of the five phases, the recommended list of participants, and the Checklists and Guidelines that help organize all of the RG and CM activities and deliverables. Lastly, as part of the testing process, our research group facilitates the comprehension of ID principles and the actual use of the Roadmap

documents by the project teams. Throughout the demonstration process, client feedback is documented via recordings, project team surveys, and summaries of collaborative meetings. Actionable observations are made and modifications to the Roadmap are registered. The goal of which is to create a verified process-based product for the market of small to medium-sized buildings that is articulate and robust enough to ensure an increase in the number of advanced energy retrofits completed in the decades to come.

1. INTRODUCTION

This paper describes the deployment of an *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* for the energy efficient renovation of small to medium-sized commercial buildings in the United States (US). Developed as part of a suite of market targeted documents, the ID process herein outlined is the result of research sponsored by the US Department of Energy at the CBEI – Consortium for Building Energy Innovation (formerly the Energy Efficient Buildings Hub), since 2012. A corresponding paper presented at this conference entitled *Advanced Energy Retrofits – Designing Integrated Design Roadmap,* by the same authors, focuses more particularly on the design of the *ID AER Roadmap* document suite.

The goal of the ID AER Roadmap project is to develop a set of process-based protocols of use during the design, construction, and operations of a retrofitted building that expands and elevates a shared definition of Integrated Design (ID) for small to medium-sized commercial buildings. The Roadmap is to be used by all contractual participants in an AER including:

- Owners + Building Managers + Financial Investors
- Architects
- Engineers (Mechanical, Electrical, Structural)
- General Contractors + Sub-Contractors + Product Suppliers
- Energy Modeling + Measurement Professionals

It is the claim of this paper that that the greater energy efficiency market currently lacks effective and scalable process-based products that offer the architecture, engineering, and construction (AEC) industry a comprehensive action plan for completing advanced energy retrofits in the particular sector of small to medium-sized buildings. A number of existing Roadmaps were reviewed but deemed incomplete for the purposes of comprehensively organizing the AEC process involved in an AER. Hence, this project is aimed at producing operational guidelines and protocols that ensure even the most inexperienced of building project teams can complete an ID AER project successfully. To this end, the *ID AER Roadmap* has been created to organize all of the requisite steps in an AER, particularly those that address integrated strategies for coordinating the full range of AEC services required in the execution of a retrofit.

2. INTEGRATED DESIGN (ID) ADVANCED ENERGY RETROFIT (AER) ROADMAP

2.1 What is an ID AER?

Within the AEC industry barriers still exist in the implementation of Integrated Design (ID) and Integrated Project Delivery (IPD) concepts. The reasons for which are many including the lack of an agreed to definition of ID amongst service providers and their clients, the lack of knowledge on the part of most AEC professionals regarding process protocols, the lack of verifiable data on the benefits of adopting ID in the completion of building projects, as well as the lack of applicable ID guidelines tailored to retrofit projects of various scales, scopes and types. Hence, in order to address this scarcity of information, this research team has conducted extensive surveys and interviews with design professionals who've adopted ID protocols in their work, as well as collected significant retrofit project data from AERs completed in the US since 2000. The goal of this work was to significantly understand whether ID was employed in the execution of AERs.

Moreover, the project seeks to recognize the particular needs of existing commercial buildings, which when smaller than 50,000 sq. ft., typically involve fewer professionals during a retrofit process and in so doing, are less likely to be informed about the value of integrating load reduction, passive design principles, and building envelopes within whole building systems engineering and design. Lastly, the project seeks to address the specific requirements and

expectations of all AEC professionals involved in an AER including the essential participation of energy modeling and measurement professionals.

2.2 Integrated Design Protocols for Retrofits

The Roadmap which developed as a result of this initial research defines Integrated Design (ID) as a collaborative set of process-based activities for identifying shared priorities and goals of use in garnering consensus amongst all members of the retrofit team. Additionally, it defines an Advanced Energy Retrofit (AER) as a building and systems based renovation of an existing structure that achieves a minimum of 50% energy savings against its pre-retrofit baseline consumption. To achieve these ends, the *ID AER Roadmap* encourages the adoption of seven ID protocols of value in any and all energy efficient retrofits, regardless of size and scale. These include:

1. Project Mission Statements
2. Participation in Integrated Design Requests for Proposals
3. Participation in Process Oriented Collaborative Meetings
4. Commitment to 'Energy Free' Design solutions
5. Commitment to Whole Building Systems Design
6. Commitment to Predictive Modeling
7. Commitment to Measurement and Verification (M+V)

2.3 Retrofit Scales

However, in addressing an all too common reality when renovating an existing building - which is, that no two retrofits projects are alike - the development of retrofit scales was required. Contrary to the construction of a new building which necessarily involves the introduction of foundations, structure, building envelopes and systems for the project to be complete, retrofits can proceed at the smallest of scales as well as at the biggest of measures. To render the Roadmap more effective and to acknowledge projects with varying levels of scope, professional expertise, and available funding, four retrofit scales were defined for the Roadmap. The four scales are identified as Lite, Partial, Substantial, and Comprehensive retrofits. Each scale offers specific guidance and recommended value added activities that are closely aligned with the project's corresponding scope. The affiliated paper presented at this conference, entitled *Advanced Energy Retrofit - Designing Integrated Design Roadmaps,* can be referenced for more information on the retrofit scales and ID protocols.

2.4 Roadmap Document Suite

More broadly, the *ID AER Roadmap* is comprised of a three-part document suite that instructs and empowers building owners, project managers, financial investors, architecture, engineering, and construction professionals, as well as energy modeling and measurement consultants with information on the value of ID in the process of completing an AER. The suite includes an *Overview* brochure that introduces ID concepts and definitions, a comprehensive *Reference Manual* that develops these concepts in greater detail, and lastly, a set of scaled *Project Team Guide* documents used by the AEC and energy professionals on the team. It is the scaled *Project Team Guide* that is the particular focus of this paper.

3. DEFINING THE SCALED PROJECT TEAM GUIDE

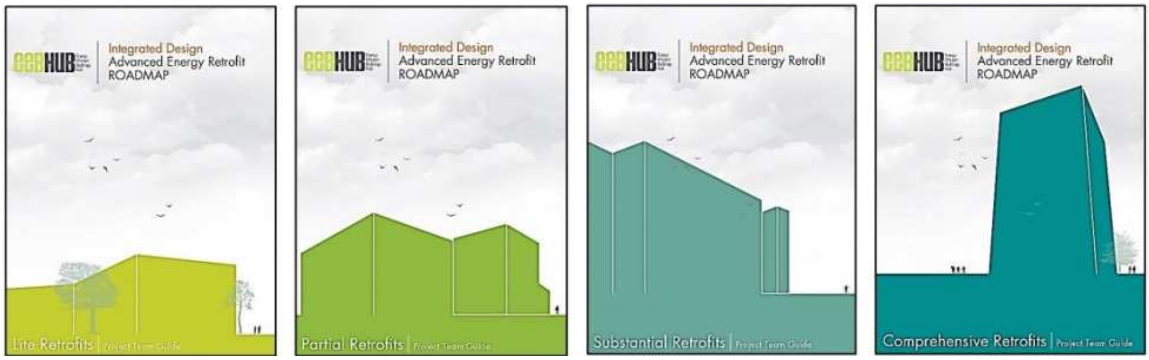

Figure 1: *ID AER Roadmap Project Team Guide* (Lite, Partial, Substantial, and Comprehensive Scale) Covers

The *ID AER Roadmap Project Team Guide* represents four separate documents of use to each of the four retrofit scales (see Figure 1). The various activities involved in all phases of the design and construction of an ID AER project are outlined and structured within these documents. The Guide has been developed for use by the range of professionals that make up the project team in order to implement the ID process within AERs. The documents within the Guide are organized based on the professional capabilities the team is required to have, which include the following:

- Project Management (PM)
- Engineering (E)
- Architecture (A)
- Construction (C)
- Modeling + Measurement (M+M)

For the purposes of this paper, the *Project Team Guide* developed for the Partial retrofit scale is specifically discussed, as this is the most common scale of retrofit in the market of small to medium-sized buildings. As defined within the Roadmap, a Partial scale retrofit is defined as a limited-scope retrofit of a building involving the participation of one or no design and engineering professional(s), completed with or without the participation of a general contractor; whose scope of work includes the purchase, installation, and commissioning of a minimum of two building systems and one building envelope component. As indicated in Figure 2, a Partial scale ID AER project is organized into five phases that take place over the course of the project, including:

1. Conceptualization
2. Design Development
3. Implementation Documentation
4. Construction & Measurement + Verification (M+V)
5. Commissioning & Post-Occupancy

Not surprisingly, all retrofit projects require conceptualization of the givens, development of the design and engineering details, as well as the development of implementation documents necessary in the physical completion of retrofits. Less typical however, is the explicit requirement that measurement and verification, as well as commissioning and post-occupancy evaluations are part of the project definition. Yet, in the case of the *ID AER Roadmap* developed by our group, these activities are essential to the ID process.

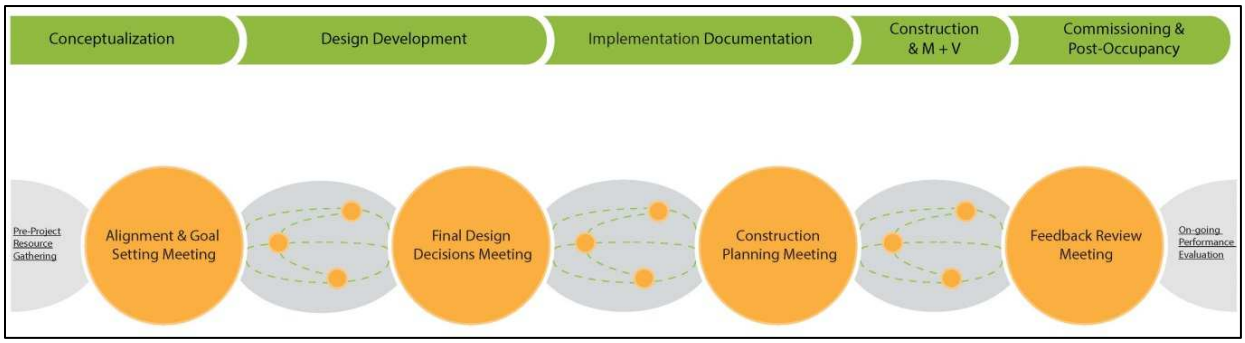

Figure 2: Integrated Design Process Diagram – Five Phases in the Partial Retrofit of an AER

Attendant to each of the five phases is a Resource Gathering (RG) stage (identified in grey) and an all-team Collaborative Meeting (CM) stage (identified in orange). During the former, all information and data necessary for the project is gathered and shared for the benefit of the entire team; during the latter, face to face encounters are organized to generate key all-team decisions necessary for advancing the project. RG stages include analysis and project development activities assigned to each professional team member based on their abilities, and typically, team members will work independently towards the development of an assigned activity. During each RG stage, the Owner and/or Project Manager may organize Sub-Team Meetings with various team members to review the development of these activities and ensure the alignment of the project to the Mission Statement. The (4) CM stages are defined as the Alignment and Goal Setting Meeting, the Final Design Decisions Meeting, the Construction Planning Meeting, and the Feedback and Review Meeting, as indicated in Figure 2.

3.1 Conceptualization

The Conceptualization phase includes the Pre-Project Resource Gathering (RG) stage and the first process oriented Collaborative Meeting (CM) stage. During the Pre-Project RG stage, preliminary project details are identified, building performance data is reviewed, and ID Request for Proposals are written and issued for contracting the full project team. The first CM, termed the Alignment and Goal Setting Meeting, is intended to give the team an opportunity to review the ID process and protocols, develop project goals in order to write a Mission Statement, and work towards the overall alignment of the project team.

3.2 Design Development

The Design Development phase also includes an RG stage and a CM stage. During this RG stage, multiple design solutions are developed by energy consultants based on the analysis of a predictive model generated for the project. During the CM, all team members participate in the Final Design Decisions Meeting to discuss and evaluate the selected energy efficient measures (EEMs) that ensure alignment with the project's Mission Statement. In addition, during this CM stage, the team is tasked with approving the final project scope, budget, and schedule.

3.3 Implementation Documentation

The Implementation Documentation phase also includes an RG stage and a CM stage, known as the Construction Planning Meeting. During the RG stage, implementation documents are developed and the predictive energy model is further calibrated. The project's construction phasing, purchase orders, and construction schedule are developed and reviewed. During the CM meeting, the Mission Statement is carefully reviewed to ensure the team members and the project remains aligned with the intended outcomes. In addition, the implementation documents, project phasing, construction schedule, and purchase orders are confirmed and approved at this meeting.

3.4 Construction & Measurement + Verification (M+V)

The Construction and Measurement + Verification (M+V) phase includes only a RG stage. This RG stage includes an accounting of the most important activities attendant to the construction of the project. Favored is the adoption of a lean project delivery method, as this sustainable form of construction management further contributes to the goals of energy efficiency and high performance building. This RG stage is also tasked with initiating the implementation of guidelines for facilitating the future M+V plan of the newly retrofitted building.

3.5 Commissioning & Post-Occupancy

The Commissioning and Post-Occupancy phase includes a final CM stage, termed the Feedback Review Meeting, and a final RG stage, which addresses the building's On-going Performance Evaluation. These activities occur after project close-out. At the Feedback Review Meeting, the results of the Commissioning plan are reviewed and the M+V plan is approved by the team. During the On-going Performance Evaluation RG stage, designated members of the project team organize the training of building personnel for future maintenance activities. Lastly, the project team decides on the scale and type of post-occupancy evaluation for more effectively measuring the value of the retrofit to the building occupant.

3.6 Document Structure

The structure of the *Project Team Guide* is organized into Toolkits for each of the phases of a retrofit, which for a Partial project are defined as the following (as shown in the Documents Map in Figure 3):

- Conceptualization Toolkit
- Design Development Toolkit
- Implementation Documentation Toolkit
- Construction & M+V Toolkit
- Commissioning & Post-Occupancy Toolkit

Figure 3 – *ID AER Roadmap Project Team Guide* Documents Map

Each Toolkit includes the documents that are necessary for that particular phase, which typically includes both Resource Gathering (RG) documents and Collaborative Meeting (CM) documents. Within both the RG documents and CM documents, there are a series of Checklists and Guidelines. The Checklists outline the integrated design and advanced energy retrofit activities, and the Guidelines give recommendations and additional information for completing the activities that are outlined in the corresponding Checklist.

Figure 4: *ID AER Roadmap Project Team Guide* Resource Gathering Checklist and Guidelines Sample

The RG documents include a listing of activities and deliverables in the form of Checklists and Guidelines for each of the professional capabilities identified above (Project Management, Engineering, Architecture, Construction, and Modeling + Measurement). For example, within the Conceptualization phase, the RG stage offers the Project Manager (PM) three Checklists of pre-project activities associated with the review of financial resources, Integrated Design (ID) Request for Proposals (RFPs), and the gathering of preliminary project information. Furthermore, the PM Guidelines within this RG stage provide supplementary information about each activity listed in the associated PM Checklist such as examples of financial incentives and recommendations for the creation and issuing of ID RFPs (see Figure 4).

The CM documents include a shared all-team Checklist and Guidelines that outline the activities completed by all professional team members within each of the CM stages. The CM stages require the full participation of all team members in order to achieve project alignment and provide for the integrated development of the project. For example, within the Conceptualization phase, the CM Checklist outlines team activities such as the identification of goals for the ID protocols including Energy Free Design, Whole Building Systems, and Predictive Modeling, as well as the development of a Mission Statement (see Figure 5).

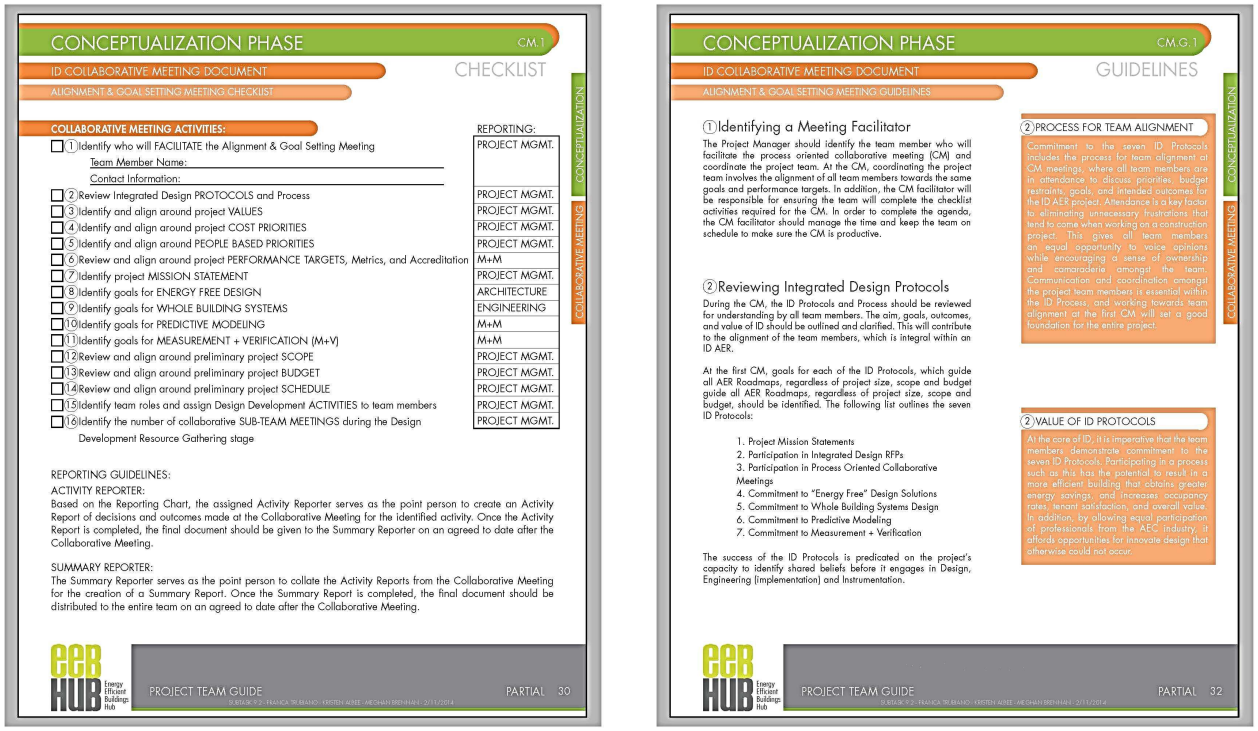

Figure 5: *ID AER Roadmap Project Team Guide* Collaborative Meeting Checklist and Guidelines Sample

Since most Partial scale retrofits have a limited number of AEC professionals involved in the process, project team members may be required to complete tasks, which albeit part of their competencies, are not typically offered as part of their services. For example, a Partial scaled project may employ an Architect, but not a Modeling + Measurement (M+M) professional. In this case, the Architect should be able to complete the M+M activities in order to maximize the advantages of ID during the AER. In fact, in defining an ID AER project team commensurate with the project budget, roles need to be explored based on the specifics of a project and assigned accordingly by the Owner and/or Project Manager at the start of the project. This offers the design and engineering process an opportunity for augmenting industry capacity, particularly as architects, engineers, and constructors are increasingly involved in energy audits, modeling, utility consumption analysis, and M+V.

4. TESTING THE ROADMAP VIA DEMONSTRATION PROJECTS

In an effort to create a market product that is articulate and robust enough to be employed in a variety of retrofit projects, it was decided that additional funding was needed to test and verify the protocols and guidelines identified

in the *ID AER Roadmap*, via actual demonstration projects. To this end, a larger core team of researchers was established to develop Consortium wide goals for evaluating the outcomes of the ID process. At present, this core team includes the Consortium's Demonstration Project Manager and Modeling and Measurement Team who are responsible for defining the particular set of energy efficiency measures (EEMs) to be completed in any one project; the original ID AER Roadmap project Research Team; and lastly, a professional ID Facilitator.

In 2012, an Advanced Energy Retrofit Opportunity (AERO) Fund was launched by the then Energy Efficient Buildings (EEB) Hub to solicit candidate demonstration projects from the market. This process resulted in the selection of five building retrofit demonstration projects, and the core team worked to develop relationships with each of the project's Owner Groups, representing; a large regional and citywide transportation authority, a religious social services non-profit, a para-public development corporation, and an inner city funded health center. Not surprisingly, of the five selected demonstration projects, all are of the Partial or Lite retrofit scale.

4.1 Overview of Demonstration Projects

The demonstration projects represent a variety of building uses including institutional, commercial, and transportation, and they involve the cooperation of public and private building owners, who range from large municipalities to small non-profits. The preliminary scope of retrofit work for each project includes a building envelope and systems based renovation focused on achieving maximum energy saving. Typical energy conservation measures that are being considered involve the replacement of heating and lighting systems, and the addition of controls and sensors.

As noted above, the five demonstration projects are each structured around the ID process outlined in the *ID AER Roadmap Project Team Guide* documents including both (5) Resource Gathering (RG) stages and (4) facilitated Collaborative Meeting (CM) stages. Via both forms of engagement, content is generated that facilitates the interaction of all project team members and an exchange of information is achieved through the distribution of Roadmap documents, presentations, and team building exercises. This highly detailed process guides the integrated development of the projects. Within each of the demonstration projects, the proposed timeline of activities, the recommended list of participants, and the checklists of activities and deliverables for each phase of the project are fully tested.

4.2 Status Update on the ID AER Demonstration Projects

At the time of the writing of this paper, one of the five projects did not proceed as intended, due to loss of client motivation. Four of the five have, however, proceeded through the Conceptualization Phase, completing the Pre-Project RG stage and the Alignment and Goal Setting CM stage. During the Pre-Project RG stage, Owner and/or Owner Groups worked alongside the Consortium's energy M+M team to establish pre-retrofit baselines for each project. By the first CM stage, it was imperative that the demonstration projects came to the meeting with a fully committed team ready to participate and align around the goal of achieving an AER. At the moment, all four projects are in the RG stage of the Design Development phase conducting advanced predictive energy modeling for each of their respective buildings.

4.3 Collecting Feedback and Impact Data on the Roadmap Deployment

All of the demonstration projects have used the *Project Team Guide* documents and at each stage of the project, the use of detailed Checklists and Guidelines was followed by the solicitation of feedback. As the testing of the ID process progresses, feedback and observations are being collected from all project team members and the results are being documented via recordings, project team surveys, and summary notes from the collaborative meetings. Based on these outcomes, modifications to the various parts of the Roadmap is taking place in order to create a market product that can eventually be used independently of the Consortium's facilitation.

5. OBSERVATIONS

The following are a number of observations that have been made after the initial deployment of the *ID AER Roadmap* via five retrofit demonstration projects targeted to save a minimum of 50% building energy against a measurable pre-retrofit baseline.

- To begin with, if clients are unmotivated, no amount of funded support of the larger process will bring them to the table to participate in such an alternative process. As was the case when one city organization, whose elected official was originally interested in executing an ID AER, terminated their involvement with the Consortium once the original project advocate was replaced in the organization.

- Additionally, the research group has noted on a number of instances that the larger ID AER process has been hampered by the fact that a fully interactive web based Roadmap interface does not exist for all of the team members to use. Without some form of advanced cloud based interactivity, the project's success is challenged by not having a shared easy to access repository that reflects the team's decision-making process. Additional funding will be sourced to enable the production of the web based Roadmap.

- Most critically, the demonstration projects have greatly benefited from the introduction of a professional ID facilitator who directs the collaborative meetings and a Consortium project manager that organizes the various parties. It is difficult to gage at this time whether it would be possible for project teams to be as effective in the use of the *ID AER Roadmap* without this dual form of informed assistance.

As the demonstration projects progress, the research team will continue to register important observations that will contribute to essential revisions of the *ID AER Roadmap*.

6. CONCLUSIONS

The advanced energy retrofit of existing buildings in the United States is a pressing issue of economic, environmental, and ethical importance. The development and deployment of the *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* for the energy efficient renovation of small to medium-sized commercial buildings is one step in addressing this issue. The three-tiered document suite produced by our team aims to instruct and empower owners, project managers, financial investors, architecture, engineering, and construction professionals, as well as energy modeling and measurement consultants with information on the value of ID in the process of completing an AER. For only in this way can a substantial improvement be made in the amount of energy consumed in the operation of buildings.

REFERENCES

Appleby, Paul. 2013. *Sustainable Retrofit and Facilities Management*. New York: Routledge.

Baker, Nick. 2009. *The Handbook of Sustainable Management*. London: Earthscan.

Burton, Simon, ed. 2001. *Energy Efficient Office Refurbishment*. London: James & James.

Liu G, B Liu, W Wang, J Zhang, R Athalye, D Moser, E Crowe, N Bengtson, M Effinger, L Webster, and M Hatten. 2011. *Advanced Energy Retrofit Guide - Office Buildings*. PNNL-20761, Pacific Northwest National Laboratory, Richland, WA.

Rocky Mountain Institute. "Retrofit Depot: True Stories." Accessed November 7, 2012. http://www.rmi.org/retrofit_depot_get_connected_true_retrofit_stories.

Tobias, Leanne, and George Vavaroutsos, eds. 2009. *Retrofitting Office Buildings to be Green and Energy-Efficient*. Washington DC: Urban Land Institute (ULI).

Trubiano, Franca. 2011. *Energy Efficient Commercial Building Retrofits: Integrated Design Interviews, Energy Efficient Buildings HUB Report*, Task 9.2 Report #1.

Trubiano, Franca. 2011. *Energy Efficient Commercial Building Retrofits: Interviews, Surveys + Analysis, Energy Efficient Buildings HUB Report*, Task 9.2 Report #2.

U.S. Department of Energy, Energy Efficiency and Renewable Energy. "Buildings Database." Accessed November 7, 2012. http://buildingdata.energy.gov/.

U.S. Department of Energy, Energy Efficiency and Renewable Energy. "High Performance Federal Buildings Database." Accessed November 7, 2013. http://femp.buildinggreen.com/

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program. "Buildings Database." Accessed July 23, 2013. http://eere.buildinggreen.com/

U.S. Department of Energy, Energy Efficiency and Renewable Energy, Building Technologies Program. "Zero Energy Buildings." Accessed November 7, 2012. http://zeb.buildinggreen.com/.

Whole Building Design Guide. "Case Studies and High Performance Building Database." Accessed November 7, 2012. http://www.wbdg.org/references/casestudies.php.
Yudelson, Jerry. 2010. *Greening Existing Building*. New York: McGraw-Hill.

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