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Advanced Energy Retrofit - Designing Integrated Design Roadmaps

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Advanced Energy Retrofit - Designing Integrated Design Roadmaps

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ABSTRACT

Today's commercial building market can ill afford the renovation of buildings by industry professionals that use archaic methods and uniformed approaches that neglect to account for the building's energy consumption. This paper advances a comprehensive solution for minimizing energy consumption in existing small to medium-sized commercial buildings. Committed to increasing the number of advanced energy retrofits completed in the United States over the next 20 years, this research team has over the past two years developed an Integrated Design Roadmap for advanced energy retrofits designed to assist project teams and building owners in achieving deep energy savings in the renovation of existing buildings. The paper's content was produced as part of a research initiative of the Consortium for Building Energy Innovation (formerly the Energy Efficient Buildings Hub) and sponsored by the United States (US) Department of Energy since 2011.

The *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* discussed in this paper contains a series of process documents of use to owners, project managers, financial investors, architecture, engineering, and construction (AEC) professionals, as well as energy modeling and measurement consultants involved in the completion of an AER, with targeted savings of 50% energy use against its pre-retrofit baseline consumption. This paper will describe the preliminary research required in the design of the *ID AER Roadmap*, as well as the overall document suite. The *ID AER Roadmap* document suite includes an Overview brochure that introduces the principle ID concepts, as well as a *Reference Manual* that details these concepts, with the final component being a *Project Team Guide* of use to professionals in the building industry.

The *ID AER Roadmap* document suite promotes the adoption of Integrated Design principles during the completion of an advanced energy retrofit. It identifies a set of seven process-based protocols key to the success of any AER, the details of which are described in this paper. The research which has served as a foundation for the Roadmap's development includes a national survey of advanced energy retrofits completed in the US since the year 2000, a series of interviews of leading professionals who practice Integrated Design, and direct engagement with members of the AEC industry to introduce the Roadmap to a larger market audience.

1. INTRODUCTION – DESIGNING THE ROADMAP

This paper outlines the design of the *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* developed for use by owners, project managers, financial investors, architecture, engineering, and construction professionals, as

well as energy modeling and measurement consultants involved in the completion of an AER in small to medium-sized commercial buildings. The resulting Roadmap and its suite of documents offer a comprehensive ID process whose protocols are of value to all members on a project team when committed to reducing building energy consumption by as much as 50% against a pre-retrofit baseline. A corresponding paper presented at this conference, entitled *Deploying and Testing Integrated Design Roadmaps for Advanced Energy Retrofits,* focuses on the initial deployment of the ID process and the *ID AER Roadmap Project Team Guide*.

Current gaps in the commercial building market continue to impede the creation of a business environment conducive to achieving deep energy savings as a result of a building's renovation. It is the goal of this project to create a process-based set of documents whose protocols can directly contribute to a reduction in the barriers confronting those who are committed to advanced energy retrofits. To this end, our project team has undertaken a series of research initiatives including a review of existing retrofit roadmaps that have already been produced for this sector of the building industry; a national survey of advanced energy building retrofits completed in the United States since the year 2000; interviews of leading professionals who practice Integrated Design; and direct engagement with members of the architecture, engineering, and construction (AEC) industry for continued validation of the *ID AER Roadmap*.

2. RESEARCH IN INTEGRATED DESIGN AND ADVANCED ENERGY RETROFITS

2.1 Analysis of Existing Roadmaps for Energy Efficient Building

Several existing roadmaps were identified and reviewed in advance of the design of the *ID AER Roadmap* discussed herein. These documents are currently available to assist building owners and members of the AEC industry in the completion of an AER. Amongst which is the important *Advanced Energy Retrofit Guide - Practical Ways to Improve Energy Performance: Office Buildings*, from the Pacific Northwest National Laboratory (PNNL). This Guide, sponsored by the US Department of Energy, is of use to facility managers of buildings between 100,000 and 200,000 square feet in guiding the retro-commissioning and partial retrofitting of a building's systems. The PNNL Guide is predicated on a 3-scale retrofit program including Existing Building Commissioning (EBCx), Standard Retrofits, and Deep Retrofits. However, this PNNL Guide over-emphasizes the value of EBCx and of operations and maintenance (O+M) for the reduction of energy given that most buildings whose systems are older than 15 years need system replacements rather than the commissioning of outdated systems. Moreover, it makes recommendations based on energy and cost data simulations for large office buildings of 200,000 square feet that are poorly aligned with the actual performance of smaller sized commercial buildings that are the focus of our work. Lastly, it is primarily written for owners and facility managers, and thus, offers insufficient information of use to the larger AEC Industry.

Equally important in the space of advanced energy retrofits is the work of the Rocky Mountain Institute (RMI) whose online and in print publication and dissemination of their *Retrofit Depot™* contributes a significant source of information for the field. While, more particularly, directed to the needs of building owners, are the *Low Carbon Retrofit Toolkit – A Roadmap to Success* from the Greenprint Foundation + Better Buildings Partnership (BBP) and the *Energy Efficient Building Retrofit Toolkit* by the Clinton Climate Initiative (CCI) + Building Owners and Managers Association (BOMA). The BBP *Low Carbon Retrofit Toolkit* makes important contributions to the field of retrofit management by identifying activities, procedures and benchmarks which when used in the renovation of an occupied tenant lease building can better ensure the success of the project. In so doing, it is a management tool written to facilitate owner/occupant relationships and suited for use at the meta-level of a project's deployment. While the CCI/BOMA *Energy Efficiency (EE) Building Retrofit Toolkit* is far more detailed and comprehensive than the BBP *Low Carbon Toolkit* by detailing the various steps and best practices required of the project team during the physical retrofit process. However, given the uneven levels of risk and responsibility binding the project team to the project owner, it is unlikely to receive wide market acceptance. It will continue to be problematic for the larger AEC industry if *"the owner has no money at risk unless the project team is able to develop a project that meets the owner's financial criteria and the owner proceeds to implement the project."* (BOMA-CCI.toolkit.pdf).

A number of these existing tools have certainly introduced the importance of using integrated design (ID) and integrated project delivery (IPD) practices and methods in the completion of AERs. However, our research has determined that the majority of these resources are not robust enough in their understanding of ID to tackle some of the most complicated issues surrounding the renovation of poorly performing buildings. These include a lack of

impartial information on products and suppliers; an over-emphasis on the singular value of building retro-commissioning (EBCx); a lack of consistency in the quality of available energy audits; a general absence of coordination among subcontractors; as well a lack of consistency in the way in which financial rate of returns (ROI) are calculated for such projects. Most critical, however, is the absence of any structured information that can be used to guide the project team and owner in the specifically measureable gains of adopting integrated design practices for the overall decision-making process incumbent to AERs. Hence, the development of the *ID AER Roadmap* document suite, discussed herein, was particularly committed to advancing clearly defined protocols for maximizing the true benefits of integration.

2.2 Advanced Energy Retrofit Survey and Data Collection

In addition to reviewing existing guides and toolkits, our research team initiated a national survey and data collection effort for gathering information about energy efficient commercial building retrofits completed in the United States. The survey had the following goals; to create a comprehensive database of advanced, nationally recognized energy efficient retrofits completed in the US in the past 15 years; to identify scope, process, technology and costs of said retrofits; and to categorize persistent barriers as well as opportunities for increasing the market adoption of AERs. A total of 54 retrofit projects were analyzed for their data and detailed interviews were conducted for 15 of the projects. (See Trubiano et al., *Advanced Energy Retrofits, A Survey and Analysis of Energy Efficient Commercial Buildings Retrofitted in the United States since 2000)*. A broad range of data points were analyzed including those associated with project financing, building system selection and design, as well as the types of integrated design activities and procedures adopted during the retrofit of selected projects. Results of this 6-month effort have served as the foundation for the *ID AER Roadmap* document suite, outlined below.

2.3 Measuring the Benefits of Integrated Design

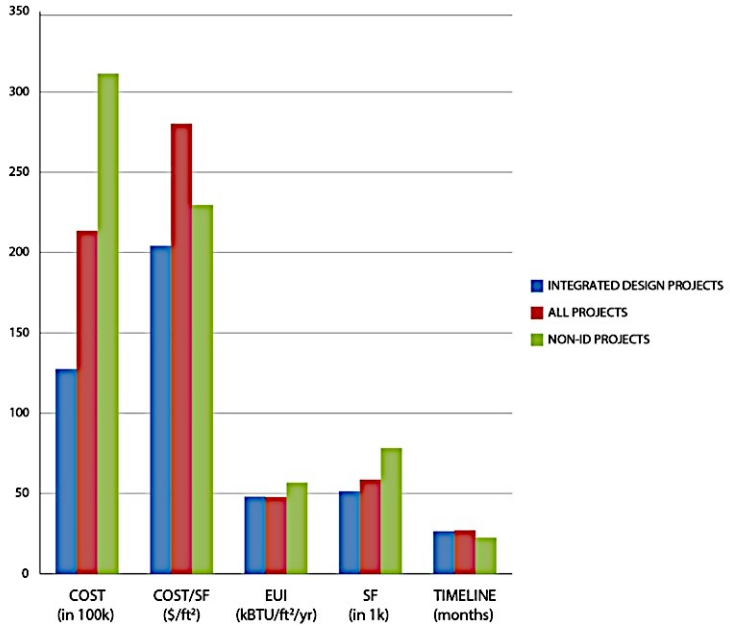

Figure 1: ID Comparison of Cost, EUI, and Timeline

A common misconception among building industry professionals unfamiliar with Integrated Design (ID) is the notion that it is more costly and time consuming to pursue ID while completing construction projects. In the AER Survey and Data collection effort described here above, questions were asked in order to evaluate the frequency with which ID methods were used in the completion of 48 of the AER projects. The survey yielded results contrary to expectations as projects that pursued some form of ID out performed projects which had not been completed using these tenets; and this, in most categories under investigation including: cost, cost/sf, and energy use intensity (EUI), as seen in Figure 1. Although the project timeline for pursuing an ID process for an advanced energy retrofit on average was slightly longer, the difference in time did not impede the project's outcome.

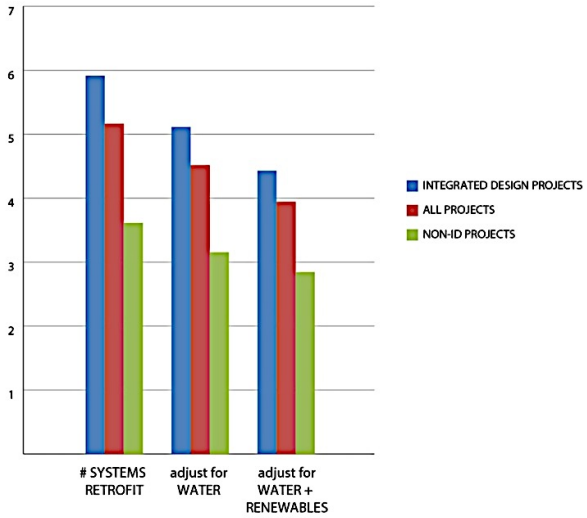

Figure 2: ID Comparison of Number of Systems Retrofitted

In addition to the financial and energy consumption benefits registered as a result of using an ID process, the 48 projects reporting data, on average, retrofitted approximately 6 systems, while non-ID projects retrofitted approximately 3.5 systems (see Figure 2). This indicates that more systems can be retrofitted at a lower cost to the building owner if using Integrated Design as compared to typical practice. Hence, notwithstanding that Integrated Design is not at this time an industry standard in completing advanced energy retrofits, the benefits a project stands to gain from adopting its tenets are greater than expected. Albeit there is a required shift in thinking and practice needed on the part of project team members, and our research of 48 nationally acclaimed retrofits indicates that the pursuit of ID is a cost and energy effective strategy for achieving advanced energy retrofits.

2.4 Integrated Design Interviews

Furthermore, the research team initiated Integrated Design interviews with eight design and construction firms, which represented a broad spectrum of practice types, from sole practitioners to large-scale firms. The interviews focused on the use of Integrated Design and Integrated Project Delivery (ID+IPD) practices to assess and evaluate the importance held by these professional process mechanisms in contemporary design practices. The interviews sought to identify successes and best practices, as well as to record the principal barriers that persist in the field that keep design professionals from more fully deploying its principles and methods. But more particularly, the survey resulted in qualitative information, which identified trends of importance to those involved in the energy efficient retrofit market.

As a result of the interviews, several conclusions were identified which served as a basis for the development of the *ID AER Roadmap*. The first of which identified the lack of a shared definition and practices of Integrated Design amongst members of the AEC Industry, as well as a lack of a shared method for assessing client motivation including the needs and goals of those participating in the ID+IPD process. The second identified the difficulties of using a universal, one size fits all, ID+IPD method, particularly for retrofits. In addition, the design professionals interviewed were committed to the collaborative protocols of ID; however, the early decision-making stages of partial building retrofits, typically organized around the 'purchase" of new equipment, excludes their participation. This represented a lost opportunity for achieving an AER project and thus, greater energy reductions. The interviews identified the need for strategies to mitigate this condition. Lastly, the interviews identified that a lack of knowledge persists in the AEC Industry regarding the measurable benefits that can accrue when using ID+IPD methods.

3. INTEGRATED DESIGN PROTOCOLS

3.1 Defining the Seven ID AER Protocols

Based on results from the preliminary research activities described here above, explicit ID protocols were elaborated in order to organize and structure the *ID AER Roadmap.* Central to the success of said Roadmap is the need for owner groups and project team members to demonstrate exceptional commitment to the seven ID Protocols it

promotes. The *ID AER Roadmap* encourages the use of seven protocols in all AER projects, regardless of project scale or scope. And, all ID AER projects would greatly benefit from pursuing the recommended activities associated with each ID protocol. These include:

1. PROJECT MISSION STATEMENT: Every project team will develop a precisely articulated set of goals detailing the project's vision, performance targets, budget constraints, and general procedural principles in order to guide and measure the project's progress and success. The entire team participates in writing and developing the Mission Statement so that all involved are in alignment with project expectations. This process gives everyone an equal opportunity to voice opinions while encouraging a sense of ownership and camaraderie amongst the team.
2. ID REQUESTS FOR PROPOSALS (RFPs): The solicitation for services from industry professionals and suppliers, administered by the Architect, Engineer, or General Contractor, but overseen by the Owner Groups must ensure that anyone who is contracted to work on the project is aware of and willing to work according to ID principles.
3. PROCESS ORIENTED COLLABORATIVE MEETINGS: The project process includes a minimum number of all team workshops throughout the various stages of the project to help align all project participants. The Mission Statement is addressed at each Collaborative Meeting to assess its application to the project, making adjustments as necessary.
4. ENERGY FREE DESIGN SOLUTIONS: All projects should introduce design strategies that are focused on attaining minimal energy usage by way of passive energy solutions and renewable energy sources. Energy Free Design solutions will be measured against predictive modeling throughout the design process to select the most effective energy efficient measures (EEMs).
5. WHOLE BUILDING SYSTEMS DESIGN: All projects should consider the added benefit of bundling two or more building systems when beginning a retrofit. In addition, all projects should encourage user load reduction and building envelope retrofits before the change out of equipment.
6. PREDICTIVE MODELING: All projects should begin with an energy audit in order to develop some form of predictive energy modeling for deciding on cost effective EEMs. Tools such as inverse modeling and forward modeling aided by a BIM model helps to envision the results of possible solutions.
7. MEASUREMENT + VERIFICATION (M+V): The performance of a building post-occupancy is measured and verified against benchmarks recorded in earlier stages of the project. M+V is continued after the project is completed to ensure the building is performing at its highest levels, providing opportunities for adjustments if needed.

3.2 Defining the ID Project Team

Within the *ID AER Roadmap* document suite, five main groups of participants are identified as being vital to the process. Each group possesses critical expertise including; Owners and their representatives (O), Architecture, Engineering, and Construction (AEC) professionals, as well as energy Modeling and Measurement professionals (M+M), as identified in Figure 3. Addressing the interests and contributions of all participants is crucial to the market wide success of ID protocols.

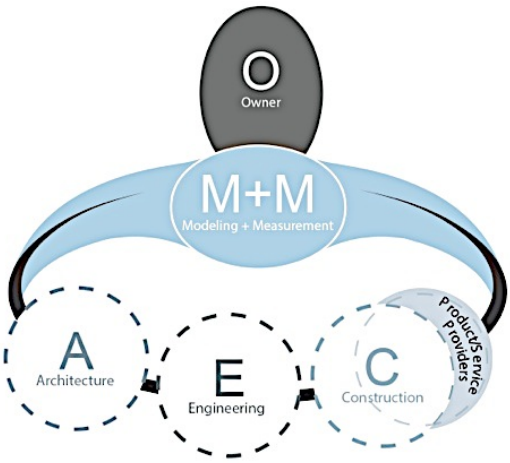

Figure 3: *ID AER Roadmap* – Project Team Diagram for Partial Retrofits

While most building construction projects typically involve the participation of Owner clients and AEC professionals, they rarely include energy Modeling and Measurement (M+M) professionals. In the completion of an AER, the M+M professional is an absolute requirement to ensure a proper accounting of the energy equation can be made for the existing building. This is noted in the above diagram with the inclusion of affiliated M+M professionals (see Figure 3). In addition, commonly within smaller scaled retrofits, not all professionals may be called upon to participate, given the budget and scope. However, in the completion of an AER, some form of M+ M is essential. The two main functions performed by the M+M professional involve initial audits, including benchmarking and utility consumption analysis, as well as some form of predictive energy modeling that simulates future performance levels.

3.3 Defining the Retrofit Scales

Clearly notable as a result of having introduced the Roadmap to leading AEC practitioners in a structured workshop at the CBEI/EEB Hub was the fact that a one size fits all ID process would be highly inappropriate in the context of an AER. Not all buildings will have the same amount of elements and systems retrofitted at the same time or all in one contract. In fact, most resources on the market today do not acknowledge the vastly varying scale and scope of retrofit projects. Hence, in order to address what are varying project sizes, budgets and schedules, the *ID AER Roadmap* identifies four separate retrofit scales, known as Lite, Partial, Substantial, and Comprehensive, as seen in Figure 4.

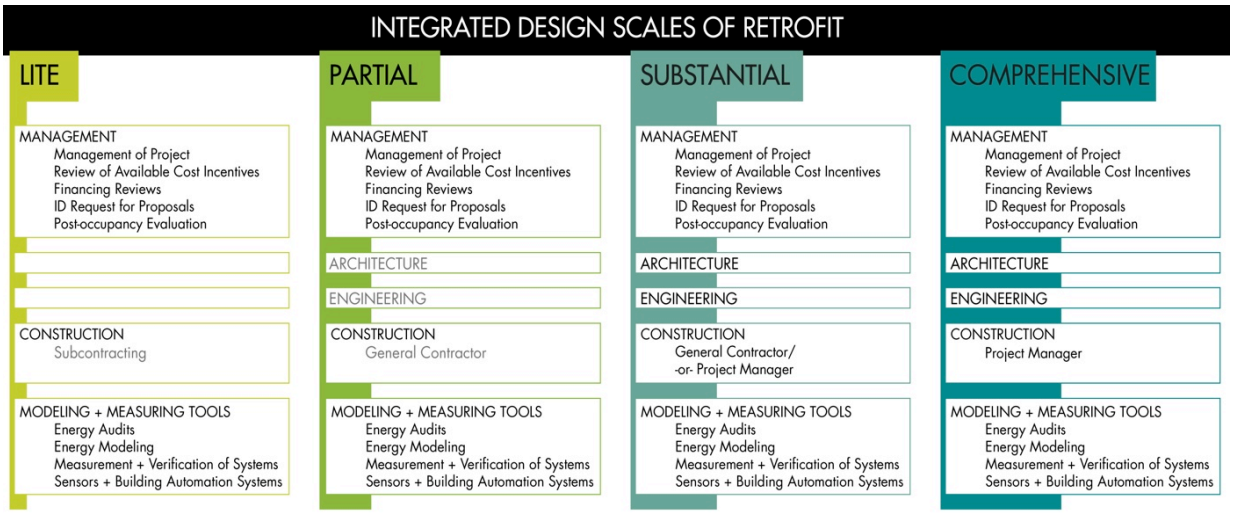

Figure 4: *ID AER Roadmap* - Four Scales of Retrofit

Lite Retrofit

A Lite Retrofit is a limited-scale project involving the participation of sub-contractors or building system suppliers in the purchase, installation and commissioning of a minimum of one new building system and the existing building commissioning of at least one existing system. Architects, engineers, and construction management professionals are not required, with product suppliers and installers typically in charge of project delivery. In a Lite Retrofit, large-scale energy modeling and post-monitoring of the building and its systems will not occur. Lite Retrofits could be limited to retro-commissioning of the building and its systems as per the AER (PNNL) Guide. Lite Retrofits have a limited set of checklist activities to ensure adherence to Integrated Design practices.

Partial Retrofit

A Partial Retrofit is a limited-scope retrofit of buildings involving the participation of one or no design and engineering professional(s), and is completed with or without the participation of a general contractor. The project includes the purchase, installation and commissioning of a minimum of two building systems and one building envelope component. Post-occupancy evaluation and minor energy modeling is recommended. Some form of M+V is recommended for post-project monitoring of the retrofit. Partial Retrofits have a more substantial set of checklist activities to ensure adherence to Integrated Design practices.

Substantial Retrofit
A Substantial Retrofit is a large-scale project involving the participation of all architecture, engineering, and construction professionals for the purchase, installation and commissioning of most building systems and building envelope components. A significant amount of energy modeling is required as is post-construction monitoring of building systems. Significant resources are dedicated to M+V for post-project monitoring of the retrofit. Substantial retrofits typically would incorporate a building automation system (BAS), post-occupancy evaluations, and post-construction energy audits.

Comprehensive Retrofit
A Comprehensive Retrofit is a maximum scope project involving the use of ID and IPD protocols for the purchase, installation and commissioning of all building systems and building envelope elements through the use of customized process protocols. Extensive energy modeling and post-occupancy monitoring is required to evaluate actual energy savings. This would involve all AEC professionals and it is distinguished from a Substantial Retrofit by client motivation - the willingness of anyone client to participate in a custom Integrated Design process and to seek deeper energy savings.

4. DESIGNING THE ROADMAP DOCUMENT SUITE

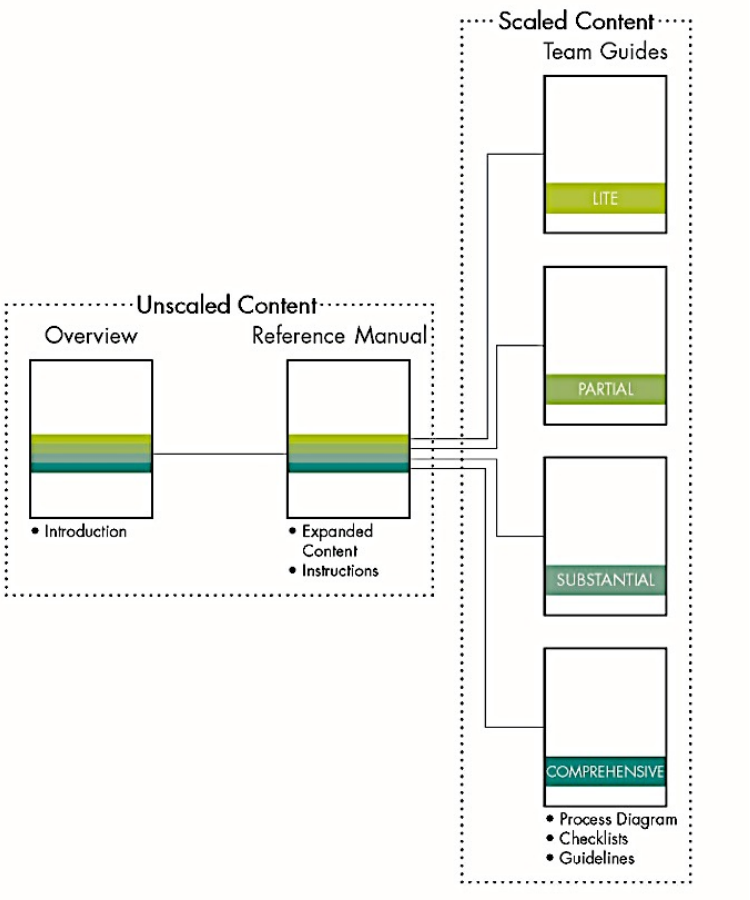

Figure 5: *ID AER Roadmap* Document Suite

The organization of the *Integrated Design (ID) Advanced Energy Retrofit (AER) Roadmap* document suite is a three-tiered structure, with each tier expanding upon and reinforcing the concepts initially presented in the previous (see Figure 5). Information is communicated to empower the building owner with the knowledge to make well-informed decisions. The sequencing of the *ID AER Roadmap* begins with a brief *Overview brochure*, which is followed by a more detailed *Roadmap Reference Manual*, and the final resource includes a set of *Project Team*

Guide documents. The first two documents offer information that pertains to all scales of retrofit, and the third includes four separate Project Team Guide documents – one for each retrofit scale.

4.1 *Overview for Small to Medium-Sized Commercial Buildings* Brochure

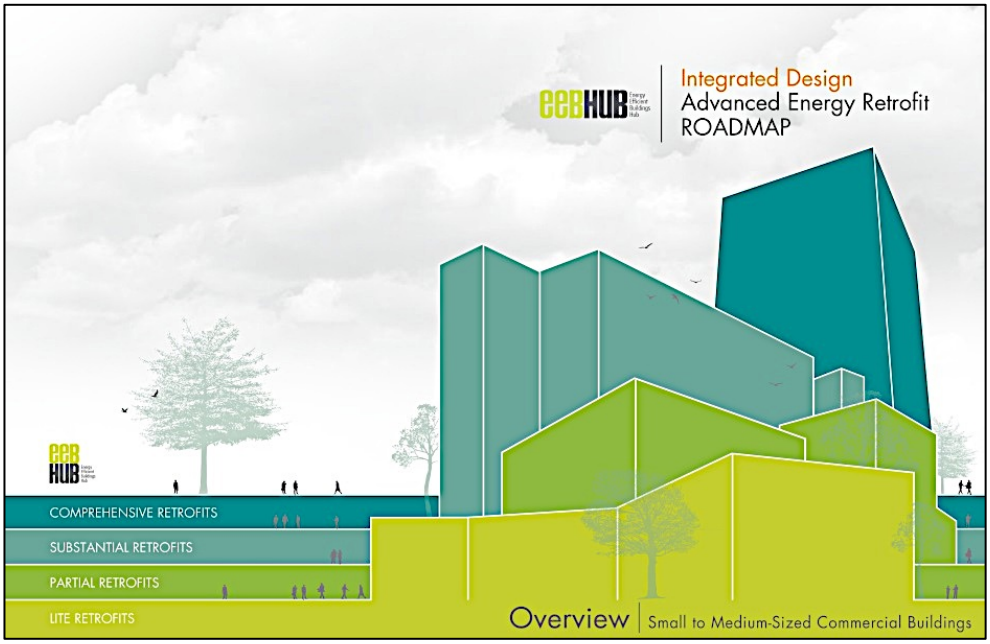

Figure 6: *ID AER Roadmap Overview for Small to Medium-Sized Commercial Buildings* Cover

As an introduction to the main concepts discussed throughout the *ID AER Roadmap,* the *Overview for Small to Medium-Sized Commercial Buildings* introduces the reader to basic ideas designed to attract the attention of owner groups, architects, engineers, general contractors and sub-contractors, product and service suppliers, modeling and measurement professionals, and all other retrofit stakeholders (see Figure 6). To this end, the topics are broad yet descriptive of the many advantages of pursuing an ID AER.

A short graphic quiz, called the "Retrofit Scale Quiz", assists the owner and/or professional in identifying the scale of retrofit most appropriate to their needs, as this represents one of the most critical decisions in the retrofit process.

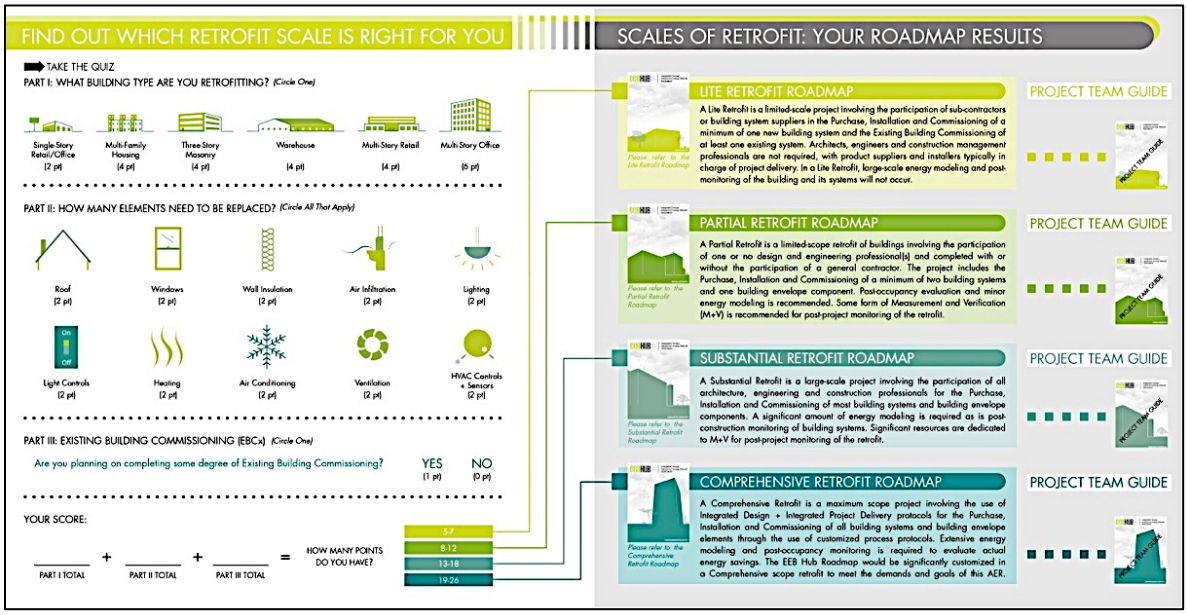

Figure 7: *ID AER Roadmap Overview* - Retrofit Scale Quiz

The quiz is divided into three parts asking simple questions about building type, building components that need to be replaced, and the potential for some degree of existing building commissioning within the retrofit project (see Figure 7). Generalizing the project in this way eliminates budget constraints and the need to have settled on the size of the project team. As such, this encourages a moment of integrated possibilities. Once each section is answered, the score is tallied and matched to one of the four retrofit scales. Albeit a retrofit scale is identified through this quiz, it is not necessarily the final project scope as this can certainly change once the project is initiated.

Additional topics covered within the *Overview* include financing an ID AER project, organizing the needed team members, and an introduction to the building systems and components typically renovated. The brochure was publically launched in November 2013 at the Greenbuild Conference.

4.2 *Reference Manual*

The larger and more extensive *ID AER Roadmap Reference Manual* addresses all pertinent information related to decision-making in the execution of an ID AER project, including; how to use the various Roadmap documents, additional resources available in the market, a discussion of Integrated Design concepts, the amount of content necessary to get started, important concepts about how to retrofit building systems and components, and lastly how to confirm the scale of retrofit to be pursued. Additionally, the *Reference Manual* further addresses the difference between Lite, Partial, Substantial, and Comprehensive Retrofits. The document reiterates the need for owners and professionals to have an exceptional commitment to the process and protocols of ID. It offers more information on the practices of measurement + verification (M+V), energy audits, benchmarking, and utility data analysis. It also includes a discussion on project Phasing – as typically, throughout the course of an AER, constraints exist that will keep a project from implementing all retrofit activities at one time; thus, requiring a phased approach. Lastly, the *ID AER Roadmap Reference Manual* reviews opportunities for increasing project scope and combining systems.

4.3 *Project Team Guide* for Lite, Partial, Substantial and Comprehensive Retrofits

The last and final tier of documents included in the *ID AER Roadmap* document suite are the scaled Project Team Guides which consist of four separate documents directed to the professionals that make up the project team. To assist in the flow of work, these documents include toolkits with designated Resource Gathering (RG) documents and Collaborative Meeting (CM) documents for each phase of an ID AER.

The Project Team Guides outline the ID process designed to guide the full project implementation, with each project being organized according to a minimum of five sequential phases; Conceptualization, Design Development, Implementation Documentation, Construction & M+V, and Commissioning & Post-Occupancy. A more detailed description of the *Project Team Guide* is offered in the affiliated paper entitled *Deploying and Testing Integrated Design Roadmaps for Advanced Energy Retrofits*.

5. CONCLUSIONS

From the continued development of the *ID AER Roadmap* document suite several conclusions can be made. The first being the need for a market product that is robust enough to service a wide variety of retrofit projects because of the varying scale, scope, and budget of most retrofits. Addressing this constraint in the renovation industry has remained essential to the definition and development of the final section of the document suite, resulting in the Project Team Guide, discussed in the paper mentioned herein above. In addition, it was decided as part of the process of developing the Roadmap, that their testing and verification was essential to their definition. As such, the *ID AER Roadmap* process is being implemented via (5) demonstration projects that are currently underway at the CBEI – Consortium for Building Energy Innovation. These projects will implement the ID process on actual AER projects and provide feedback for the enhancement of the Roadmap documents for use in the AEC industry. Additionally, the research group has determined an interactive web based interface will be integral to the successful deployment of the Roadmap documents. The creation of a cloud-based interface will ensure greater team collaboration and organization, as well as aid in the dissemination of the Roadmap.

More generally, today's commercial building market can ill afford the renovation of buildings by industry professionals that use uniformed approaches that neglect to account for the building's energy consumption. In order to achieve a unified approach and greater energy savings within retrofit projects, the *ID AER Roadmap* document

suite offers a comprehensive solution geared towards simplifying the use of ID practices within the AEC industry with the goal of increasing the market adoption of ID AERs.

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