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Small buildings, big impacts: developing a library of small commercial building energy efficiency case studies

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Abstract

Small commercial buildings, or those comprising less than 50,000 square feet of floor area, make up 90% of the total number of buildings in the United States. Though these buildings currently account for less than 50% of total energy consumption in the U.S., this statistic is expected to change as larger commercial buildings become more efficient and thus account for a smaller percentage of commercial building energy consumption. This paper describes the efforts of a multi-organization collaboration and their demonstration partners in developing a library of case studies that promote and facilitate energy efficiency in the small commercial buildings market as well as a case study template that standardized the library. Case studies address five identified barriers to energy efficiency in the small commercial market, specifically lack of: 1) access to centralized, comprehensive, and consistent information about how to achieve energy targets, 2) reasonably achievable energy targets, 3) access to tools that measure buildings' progress toward targets, 4) financial incentives that make the reduction effort attractive, and 5) effective models of how disparate stakeholders can collaborate in commercial centers to reach targets. The case study library can be organized by location, ownership type, decision criteria, building type, project size, energy savings, end uses impacted, and retrofit measures. This paper discusses the process of developing the library and case study template. Finally, the paper presents next steps in demonstrating the efficacy of the library and explores energy savings potential from broad implementation.

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Keywords: Small commercial buildings; building energy efficiency; case study

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1. Introduction

The commercial building sector consumes nearly 40% of all US energy, which is more than the transportation or industry sectors ("Energy Efficiency Trends", 2008). With small commercial buildings accounting for 90% of the commercial building sector by count, and 47% of the commercial building sector's energy use, decreasing energy usage in small commercial buildings could make a major impact on energy in the US ("Saving Energy, Money, and Jobs", 2013). In fact, there could be as much as a 17% reduction in total energy use if small commercial buildings were targeted for energy efficiency ("Realizing the Energy Efficiency", 2013). Through a multi-organization collaboration between Lawrence Berkeley National Laboratory, Architecture 2030, and 2030 Districts as Demonstration Partners, the team created resources specifically for small commercial building owners, operators, and designers looking to improve building energy efficiency. As part of this collaboration, the team created a case study template and library for energy efficiency projects in small commercial buildings in order to benefit small commercial stakeholders interested in achieving building energy savings. This template and library leverages current case study databases, with useful search features along with practical visuals and figures, and succinct information, while still addressing barriers to energy efficiency identified for the small commercial sector.

Small commercial building sector energy use is concentrated into relatively few building types, making large energy savings possible with focus on a limited suite of building types. Energy use in these buildings is also very concentrated – over a quarter of total energy use goes towards lighting, thus in focusing on lighting efficiency in a few building types, large energy savings can be achieved. Figure 1 shows the full breakdown of energy end-use for the commercial sector ("Energy Efficiency Trends", 2008). Note that the gray section is a statistical adjustment.

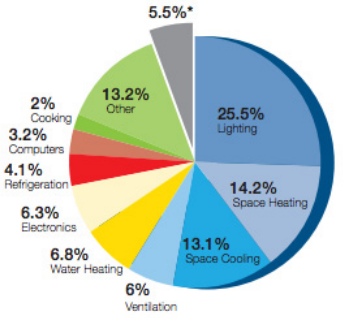

Fig. 1: Commercial energy end-use breakdown, 2005 – Department of Energy

This paper presents the work of a multi-organization project team participating in the U.S. Department of Energy's "Better Buildings: Commercial Energy Efficiency Solutions" program. Specifically, this team focuses on building Small Commercial 2030 District Programs & Toolkits aimed at addressing barriers to energy efficiency in the small commercial building sector. The paper describes the small commercial buildings market, the multi-organizational team's composition and roles, and presents one tool in the Small Commercial Toolkit, case studies. Specifically, the paper presents the case study template and the case study library, each of which support energy efficiency projects in the 2030 Districts (Architecture 2030, 2015). Note this paper presents work completed in year one of a two-year project period.

2. Background: Small Commercial Market

With small commercial buildings making up 90% of the commercial building sector by count, this sector represents a great potential for energy savings in commercial buildings ("Saving Energy, Money, and Jobs", 2013). However, barriers exist that prevent small building owners and managers from improving energy consumption in comparison to large commercial building owners and managers; this is mainly due to the lack of capital and resources available to owners, and the different priorities that small businesses have compared to large businesses. Small commercial building owners, most often individual or family entities, do not have the time or money to focus on improving energy efficiency while also maintaining a profitable business. Toolkits and management programs are often geared towards large building owners, who can hire out a professional team to manage these energy projects, whereas small building owners may need resources that require less technical expertise and time to implement, e.g., user-friendly "checklists" rather than a detailed sequence of operations.

The small commercial market is also made up of very different demographics in terms of ownership, management, use of building, and physical building traits. Figure 2 illustrates a breakdown of ownership and management in the small building market, based on a survey conducted by the National Trust for Historic Preservation ("Realizing Energy Efficiency", 2013).

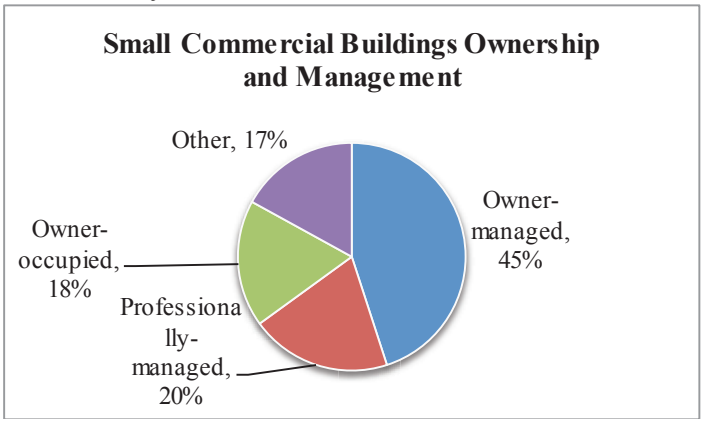

Fig. 2: Small Commercial Buildings Ownership and Management – National Trust for Historic Preservation

Most buildings fall into the category of tenant-occupied, and owner- or professionally-managed, in contrast to large commercial buildings that are often professionally managed. In the case of small commercial buildings, owners are more often the decision-makers, and also tend to be more concerned about convenience and business identity than energy and they may lack the time, money, and knowledge to make decisions based on other criteria.

The physical characteristics of buildings in the small commercial sector also vary greatly – not only compared to large commercial buildings, but also within the market itself. The small commercial buildings market comprises multiple building types for different businesses in the market, including offices, mixed-use main street buildings, retail space, and food centers. Therefore, each building has specific needs, which makes it difficult to develop one-size-fits-all toolkits or other resources for energy efficiency. Luckily, a few building types account for a majority of the energy use in the small commercial sector, thus allowing for concentration on those specific types that will lead to energy reduction. Namely, these include Food Service, Main Street (attached, multi-use), and Strip Malls.

3. Project Team

The Lawrence Berkeley National Laboratory (LBNL) and Architecture 2030 partnered to create a 2030 District toolkit for small commercial building energy efficiency, offering small commercial buildings resources to make participation in the popular Architecture 2030 Districts easier. Specifically, LBNL is the Lead and Technical Partner, while Architecture 2030 is the Deployment Partner. The team also works with four Demonstration Partners: the City of San Jose, the Seattle 2030 District, the Pittsburgh 2030 District, and the Cleveland 2030 District. Arizona State University (ASU) is a subcontractor of LBNL, and focused their efforts on developing a case study template and library. ASU engages the Demonstration Partners to collect case studies based on their projects. LBNL's primary responsibilities include developing the technical tools that each of the 2030 districts use, and project management. Architecture 2030 is responsible for developing the entire small commercial building energy efficiency program and toolkit, hosting the website, and coordinating all activities between the members of the project team and Demonstration Partners. The Demonstration Partners will pilot technical tools that Lawrence Berkeley National Laboratory develops, implement energy efficiency measures within their districts, and submit baseline and post-retrofit energy data to the project team for use as program examples. Table 1 shows the responsibilities of each team member.

Table 1. Team member roles and responsibilities

Team Member	Role	Responsibilities
Lawrence Berkeley National Laboratory (LBNL)	Lead Applicant, Technical Partner	• Technical tool development • Project Management
Architecture 2030	Deployment Partner	• Deploy program and toolkit • Host website • Coordinate activity between project team and demonstration partners
City of San Jose, Seattle 2030 District, Pittsburgh 2030 District, Cleveland 2030 District	Demonstration Partners	• Pilot technical tools • Implement efficiency measures • Submit baseline and post-retrofit efficiency numbers
Arizona State University	Subcontractor to LBNL	• Lead case study library and template development • Support Demonstration Partners and LBNL while template is implemented • Work with Demonstration Partners to produce case studies from pilot projects

4. Case Study Template

In order to create an effective and usable case study template, the authors reviewed case studies from related databases. Case study databases reviewed include the New Buildings Institute ("Resource Library", 2014), Architecture 2030 ("Architecture 2030: Case Studies"), 2030 Palette ("Case Studies", 2030 Palette Blog), Rocky Mountain Institute's Retrofit Depot ("Case Studies", Retrofit Resources) and the Department of Energy's Commercial Buildings Resource Database ("Commercial Buildings"). The authors assessed the following case study attributes in each of the databases: visuals and/or figures, search features, consistency, amount of information available, highlighting and/or summarizing of data, legibility, ease of online and print reading, project photos, company or firm branding. Table 2 presents an excerpt of the authors' assessment of case studies reviewed.

Table 2: Research findings from existing databases

Necessary Feature	Palette case studies	Seattle 2030 case studies	NBI case studies	Architecture 2030 case studies	DOE Commercial Building Partnerships case studies	High Performance Buildings Database
Visuals and Figures	Yes, but only a few and not very detailed.	No visuals or figures.	Yes, but slightly too many words.	No figures or visuals available on the 2030 website, but available through links.	Yes, many visuals and figures.	Some tables shown, but overall not many.
Consistent Format	Yes, there is a consistent format.	Yes, consistent format.	Yes, all have similar format.	Data on the page is consistent, but linked data not all same.	All have similar format, not exact.	Yes, all have same format.
Search Features	Yes, there is a column with keywords	No search features.	No search features.	Yes, extensive search features.	Yes, searchable with numerous filtering options.	Yes, many search features.
Entire case study available, no links	Yes, entire case study is available, but not specific.	There are no links, but not specific.	Yes, entire case study available.	No, case studies are linked and some links don't work.	Yes, entire case study available.	The entire case study is available, but is separated
Features summarizing data, or highlighting important data	No features	Yes, column on side	Yes, features and summary	Yes, the only information available is a summary of data.	Yes, summarization of important stats and data.	There is an overview at the beginning.
Legible, modern, minimalist, easy to read	Yes, but more casual than technical.	Not modern, but legible.	Yes, very legible, modern.	Unanswerable. Many case studies are not accessible.	Yes, very legible and easy to read.	Legible, but organization could be better.
Pictures/renderings of site	Yes, there are pictures of the building(s).	Yes, there are pictures of the site.	Yes, picture of completed building.	Yes, there are pictures of the building.	Yes, pictures of completed building.	Yes, "Images" section.
Company/Firm branding	No, just branding for Palette blog	Building owner is mentioned	Owner is mentioned, branding for NBI	Architect/Engineer and Owner is mentioned	No, most branding it for DOE	Owner and project team mentioned.
Easy to print	No, do not print well.	Prints well formatted as PDF	Prints well formatted as a PDF	No, do not print well.	Yes, print well – formatted as PDF	Only print one section at a time, prints well.

Based on the research findings, the authors determined the case study template should be a user-friendly web form, with all necessary information legible and straightforward. The template is a fill able web form that can easily be printed into two pages, with the first page providing quick project highlights and the second page providing more detail. Figure 3 shows the first page of an existing case study utilizing the case study template from the 2030 Districts website (note this is presented as two pages due to size limits, but both the left and right hand figures comprise a single printed page). The top of the first page lists the 2030 District or Demonstration Partner associated with the project, the title of the project, and associated energy savings as both a percentage of consumption reduced and as a cost savings. The energy savings is prominent at the top, as research indicated energy savings would be a motivating factor for a user deciding which case studies (s)he may be able to replicate. The left-hand column provides a summary and photo of the project, while the right hand column presents a quote about the project, and the top decision criteria for implementing the project. The decision criteria table covers the reasons why the owner pursued the energy retrofit project. At the bottom of the first page, there is a table summarizing useful, but basic statistics on the project like building type, location, and cost. The first page also includes a table presenting challenges or lessons learned from the project, and a space for owner or tenant contact information. The challenges or lessons learned table comprises the issues the project team dealt with, how they dealt with them, if they succeeded or not, and what they would do in the future. This first page covers all of the most important aspects of the projects, while being succinct and visually appealing. All information on the first page is considered "required." The user inputs pre- and post-retrofit energy consumption and utility bill costs, and the template automatically calculates the percentage reductions.

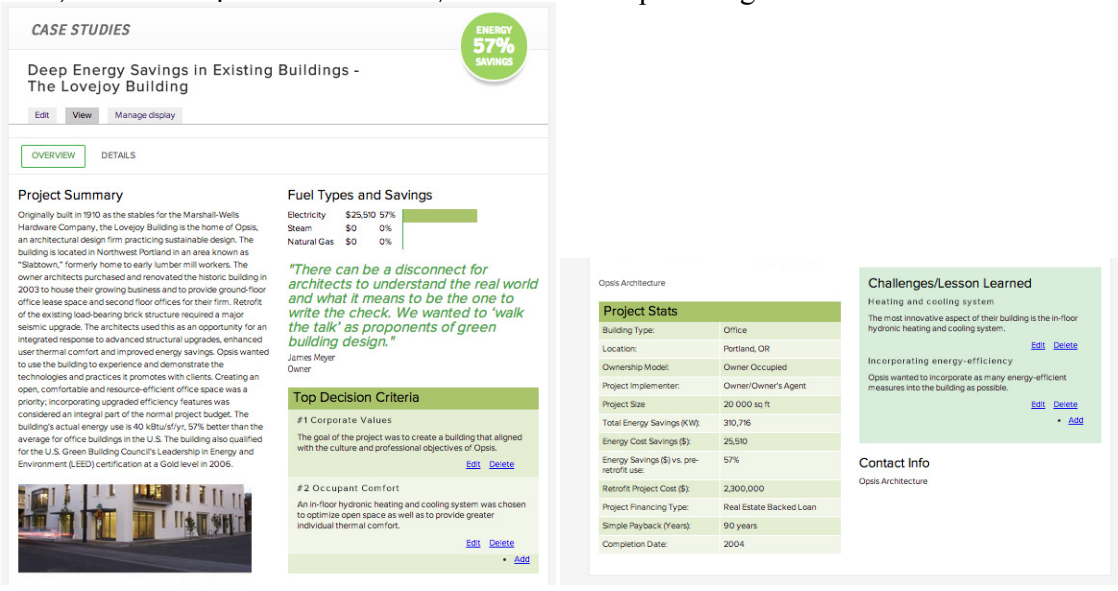

Fig. 3: First page of case study template with existing case study – 2030 Districts

Figure 4 shows the second page of an existing case study utilizing the case study template from the 2030 Districts website. The second page goes into further detail about the project, but maintains a focus on information that helps future users replicate the project. This page presents specific retrofit measures implemented, with descriptions on these measures and associated end uses. This page includes space for user-defined input, e.g., photos or videos, if applicable, and a text box for including additional information. This page includes a table of retrofit measures

considered, but not implemented, with a description of that decision. A recommendation quote is also shown on the second page, which is usually related to challenges the project team faced, or a process that went particularly well for the team. Finally, this page includes references for those looking to gain more knowledge on the project. All second-page content is considered non-essential, but still important to those interested in learning more about the project. The most important part of this page is the description of retrofit measures implemented, and is also one of the largest sections on the page.

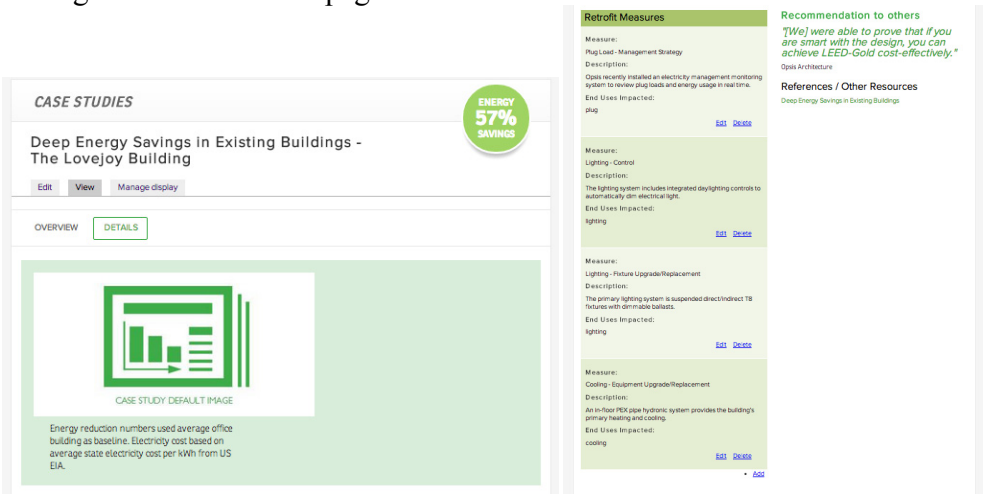

Fig. 4: Second page of case study template with example case study – 2030 Districts

5. Next Steps on Case Study Library

At the time of this publication, the case study template is complete and the case study library includes existing case studies from other databases. In year 2 of the project, ASU will expand the case study library to include Demonstration Partner projects. This library will serve as a record of Demonstration Partner projects and will help provide evidence for small commercial owners that energy savings are possible (in both monetary and electricity savings). Moreover, the case study library will include specific recommendations about how to make energy efficiency projects successful for small commercial buildings. The case study library will also document the Demonstration Partners' experiences with other tools in the small commercial toolkit. As the Demonstration Partners report energy savings goals, strategies, etc. and also implement pilot projects, ASU will help the Partners document that information and populate the case study templates for their projects.

6. Discussion

Throughout the project, the main goal is to address the following barriers that the small commercial sector faces: 1) access to centralized, comprehensive, and consistent information about how to achieve energy targets, 2) reasonable achievable energy targets, 3) access to tools that measure buildings' progress towards targets, 4) financial incentives that make the reduction effort attractive, and 5) effective models of how disparate stakeholders can collaborate in commercial centers to reach targets. With the implementation of the case study template and library, stakeholders within the small commercial sector will be able to gain knowledge on real energy efficiency projects that other owners have pursued and reported, and also understand the possible energy savings associated with completing an energy efficiency project within their own

building. The technical tools that LBNL is creating will work concurrently with the case study library to convince owners to participate in the District, since both the tools and the library will be easy to follow and use for small commercial sector owners that may not have the knowledge base, time, or money to complete the project. With the Demonstration Partners engaging key stakeholders in their districts, and also setting achievable energy savings goals, stakeholders will be able to effectively reach energy goals for their building, and also work together to reach energy goals for the district, all the while creating case studies that can further the case for energy efficiency in the small commercial sector and help encourage broader deployment of energy efficiency retrofit projects in this market.

6.1. Future Work

With the project moving forward as quickly as possible in order to implement these technical tools and library for the pilot projects to use, the authors continue to seek feedback on how to improve upon the current template and library. For instance, how can interested stakeholders be attracted to the case studies and library? Should interested parties just join into the current case study library with the current template, or should different groups develop their own template for the library based on their different needs? As of right now, the Demonstration Partners and eventually all 2030 Districts will be contributing to the case study library, all using the same template. Thus, the library will scale up. At that point, it may make sense to link this library to other databases, allowing different user groups (e.g., Better Buildings partners) to create their own templates. In the future, growing the library and potentially changing the template may be key to reaching stakeholders and energy savings targets throughout the small commercial sector.

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