A REGENERATIVE APPROACH TO DEVELOPMENT AND CONSTRUCTION OF BUILDING ENERGY RETROFIT PROJECTS

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by

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ABSTRACT

The retrofit of buildings to improve energy performance represents a vast opportunity in the construction market with the potential to create jobs, reduce energy demand, and achieve environmental benefits. Multiple challenges need to be overcome to unleash this potential and realize the benefits of investments in improving building energy performance. While large facilities often have easily predictable energy saving potential at scales that are attractive to the financial industry, they are often pursued in a manner that achieves only “low hanging fruit” for short term economic return. As a consequence, they often fall short of their potential to be pursued as a long term solution. Small sized buildings face even more challenges often related to the lack of the owners’ abilities to manage and finance energy efficiency improvements. The goal of this research is to develop a framework that supports the continuous improvement of processes involved in developing energy retrofit projects for small sized commercial buildings. The concept of regenerative thinking guided the investigation of value creation and exchange in networks of the stakeholders of a given energy retrofit. Characterization of investment risk in the value adding processes enables more informed investment decisions required to bring a retrofit project to optimal fruition. This enables the identification of high-risk investments during the process that can be elevated as key decisions to prove the investment risks are proportionate to the value being offered. The reduction of project development costs and risks can then contribute to a market-driven expansion of these project and the resulting economic, ecological, and social system effects. In addition, process improvement interventions can be designed and evaluated by their potential and actual effects in lowering the capital investment required to pursue retrofit projects. Key elements of this framework are developed through case studies, focus groups, and interviews. In conclusion, research results examining the value of the framework in improving the business development process for small commercial building energy retrofit projects are presented.
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1 Introduction

In the United States, residential and commercial buildings consume over 70% of the electrical power generated and 40% of primary energy; They are responsible for 40% of CO2 emissions from combustion (EIA, 2018; EPA, 2016; Pérez-Lombard, Ortiz, & Pout, 2008). When constructed, buildings remain in use for many decades. For example, in the U.S. the median age of commercial buildings in 2012 was 32 years (CBECS, 2015). When viewed as a business opportunity, energy retrofit projects represent a unique segment of the building design and construction market (Ruparatha, Hewage, & Sadiq, 2017). The dominant process in which energy efficiency construction projects are initiated is through regular operations and maintenance programs or through an unsolicited proposal by energy services firms (A. Lewis, Elmualim, & Riley, 2010). Energy Services Companies (ESCOs) typically focus on large commercial buildings and industrial facilities because of the economies of scale for both the retrofit construction and the energy savings potential that can be more easily quantified. These projects are appealing to third-party finance and investments and require no/low capital investment by the building owner. Small commercial retrofit projects are typically unattractive for the traditional ESCO models largely due to the high amount of effort required to develop projects and the small scale of likely return on investment in business development. A significant amount of research has been carried out to investigate the challenges of energy retrofit projects (Ma, Cooper, Daly, & Ledo, 2012). Despite the challenges, small and medium-sized buildings represent a significant part of existing buildings (Navigant, 2016). In the United States, the small/medium buildings market accounts for 99% of all existing commercial buildings and approximately half of commercial building energy use; this sector, with 5.6 million buildings and 87 billion square feet accounts for 9% of total U.S. primary energy use (CBEI, 2016). Further, many of these small and medium-sized buildings have much higher energy costs than larger buildings. For example, food sales and services (e.g. convenience
stores and restaurants) are the most energy intensive type of commercial buildings, three times higher than average expenditure for all commercial buildings - see Figure 1.1. The challenging aspects of small to medium size restaurants and convenience stores, coupled with the significant potential for energy savings in these buildings represent a valuable test market for a new approach to unleash the potential of retrofiting these projects for energy improvements, and are thus the focus of this research.

Figure 1.1. National Average Energy Expenditure, 2012 (CBECS, 2016)

This research seeks to advance building energy efficiency through the introduction of new methods and processes leading to financially viable energy retrofits of small commercial buildings with an emphasis on restaurants and convenience stores. The specific goal is to create a holistic framework that supports the evolution of the processes used to pursue energy retrofits of small sized commercial buildings, in a way that optimizes return on investment risks during the project development process and facilitates value exchange between stakeholders, so that building owners, occupants, designers, builders, manufacturers and policy makers experience systemic economic, environmental, and social system effects of a vibrant and vital energy services industry. Key elements of the framework are developed through case studies, focus groups, and interviews and risk management techniques are utilized to inform decision making process during the business
development. A current initiative supported by the Pennsylvania Department of Environmental Protection (DEP) is examined as context for design and evaluation of the framework.

1.1 Organization of Dissertation

The organization of this dissertation is as follows. Chapter 2 is a review on literature and evaluation of previous research in building energy retrofit to establish the area of study and to provide a theoretical foundation for the research. Chapter 3 outlines the research goal and methodology to address the research questions. In Chapter 4, the existing industry practices are mapped after studying and interviewing stakeholders of energy retrofit projects. In chapter 5, a framework is proposed for the systemic pursuit of the retrofit delivery process in a regenerative approach. Chapter 6 presents the results of evaluating the proposed framework in tracking case studies of small commercial buildings energy retrofits. Chapter 7 gives a summary of dissertation outcomes and contributions as well as directions for future work.
2 Literature Review

To provide a theoretical foundation for the research, in this chapter a review of relevant literature is provided. This research draws from multiple systems of existing literature: (1) Building energy characterization processes, (2) Competency model for energy auditors, (3) Student-led building energy assessment, (4) Business development in energy retrofit industry, (5) Project delivery methods, (6) Sustainable and lean practices. A background of relevant research and practice in each of these systems is provided along with the key factors and observations contributing to the research design. Finally the regenerative design and development is introduced as an emerging concept for making sense of complex domains (See Figure 2.1)
2.1 Building Energy Characterization Processes

Building energy characterization, commonly referred to as energy auditing or energy assessment, refers to the actions taken to understand buildings energy profile and describe the factors contributing to building energy use (Baechler, Strecker, & Shafer, 2011). The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) defines three tiers of energy audits that reflect a continuum of increasing effort and investment (Michael P. Deru, 2011): Level I Audit focuses on-site assessment and preliminary assessment to identify low-cost energy-saving strategies and the potential for larger opportunities through brief inspections of buildings and assessment of energy bills. Level II Audits focus on more detailed energy surveys and analysis which provides more information on energy use in buildings and potential energy savings. Level III Audits include the design of retrofit packages and economic analysis to inform detailed recommendations and financial return on investment for major capital investments for energy saving strategies. The process of characterizing buildings’ energy systems for the purpose of recommending upgrades in levels I, II, and III is pursued in a variety of methods as categorized and summarized below:

2.1.1 Simulation-based methods

Simulation-based approaches are most commonly recognized through use in building energy modeling software, such as EnergyPlus, and are widely used in design and research (Harish & Kumar, 2016). These methods include dynamic and steady-state modeling, which uses software programs to simulate building energy profiles while applying building parameters, including but not limited to: orientation, mechanical system characteristics, and dynamic operation parameters to determine end-use energy consumption. Steady-state models offer the users a quick modeling
method, leveraging a small number of inputs with transparent calculations resulting in reproducible energy profiles (Kim, Yoon, & Park, 2013). Dynamic simulations are capable of a higher level of modeling and can account for the complex systems not suited for steady state models, such as daylighting and energy management systems (Crawley, Hand, Kummert, & Griffith, 2008). Creating building energy models can be financially prohibitive, require technical knowledge, and time commitments not suited to small commercial building (SCB) stakeholders (Hong, Chou, & Bong, 2000). In conclusion, while simulation methods have their merits in level III audits of larger projects, many small commercial building owners and their tenants cannot use these methods.

2.1.2 Measurement-based methods

Measurement-based approaches use empirical data to determine building energy profiles and include monitoring-based methods such as sub-metering or outlet monitoring methods (Gandhi & Brager, 2016; Ji & Xu, 2015; Zhao, Lasternas, Lam, Yun, & Loftness, 2014) and non-intrusive load monitoring (NILM) (Berges, Goldman, Matthews, Soibelman, & Anderson, 2011; Farinaccio & Zmeureanu, 1999; Norford, Leslie K., 1996). Additionally, measurement-based methods include energy bill disaggregation, which uses energy bills to disaggregate using top-down or bottom-up methods (Wang, Yan, & Xiao, 2012). Measurement-based approaches are used for detailed energy analysis in audit level II and III.

2.1.3 Observational methods

Observational methods are a subset of data collection and building characterization including visual inspection of building envelope, mechanical systems, and occupied spaces
The goal of observations is to detect tell-tale indicators of potential energy improvements. Level I, Level II and Level III site assessments each include some degree of investigation into existing building systems, operations and maintenance procedures, and typical building occupancy. The duration of the onsite assessment varies depending on building size and the level of audits; in particular, Level III audits may require the auditor to conduct multiple site visits and meter equipment to capture usage data (Baechler et al., 2011). A significant challenge in the use of observational methods is the diversity of potential conditions that might be encountered and the variable skill sets required to interpret observations.

2.1.4 Barriers to act upon energy efficiency measures

Building owners or occupants must ultimately choose to implement energy efficiency measures revealed by building energy audits. The decision for choosing or not choosing to implement an energy efficiency measure is influenced by both barriers and motivators. Table 2.1 presents a list of commonly experienced barriers based on the taxonomy presented by Sorrell et al. (Sorrell et al., 2000) and compiled in the work of Trianni and Cagno (Trianni & Cagno, 2012). Barriers are defined as “obstacles to the efficient use of energy” (Weber, 1997) and have been studied extensively for their influence on the residential and commercial communities (Fleiter, Schleich, & Ravivanpong, 2012; Kostka, Moslener, & Andreas, 2013; Murphy, 2014; Rohdin & Thollander, 2006; Schleich & Gruber, 2008; Trianni & Cagno, 2012).
Table 2.1 Decision to act upon energy efficiency measures: A list of commonly experienced barriers

<table>
<thead>
<tr>
<th>Economic, Non-Market Failure</th>
<th>Economic, Market Failure</th>
<th>Behavioral</th>
<th>Organizational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to capital</td>
<td>Fragmentation</td>
<td>Bounded rationality</td>
<td>Culture</td>
</tr>
<tr>
<td>Heterogeneity</td>
<td>Imperfect information</td>
<td>Credibility &amp; trust</td>
<td>Energy manager lacks influence</td>
</tr>
<tr>
<td>Hidden costs</td>
<td>Lack of information</td>
<td>Form of Information</td>
<td>Lack of sub-metering</td>
</tr>
<tr>
<td>Risk aversion</td>
<td>Principal-agent relationship</td>
<td>Inertia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Split incentive</td>
<td>Resistance to change Values</td>
<td></td>
</tr>
</tbody>
</table>

While energy auditing provides information on energy conservation strategies, current methods are largely focused on financial savings and packages of measures with the best return on investment (Fuller et al. 2010; Ingle et al. 2012). In current practices, investment is often wasted in collecting detailed data, instrumentation, writing long and technical reports, detailed energy models and saving analysis for projects that do not result in actual retrofits. Further, most of the research in the adoption of audit recommendations is limited to the residential sector. For example, Palmer et al. (Palmer, Walls, Gordon, & Gerarden, 2013) surveyed 479 energy service providers (ESP) across the U.S. to explore how audit information is provided to homeowners, and how homeowners use this information. Their conclusions suggest that the majority of homeowners are unaware of what an energy audit provides and the costs associated act as a significant barrier to purchasing an audit. They found that an estimated 30% of homeowners receiving an audit made no investments post-audit. A national survey of homeowners in the Netherlands observed similar low adoption rates; 19% of audit recipients invested in energy retrofits, estimating 60 to 70% of energy retrofit recommendations were ignored (Murphy, 2014). Low investment rates were also seen in studies
concluding energy audits had little to no effect (McDOUGALL, CLAXTON, & RITCHIE, 1982), while subsidies had a little influence on adoption rates (Hirst, White, & Goeltz, 1985). Moreover, the audits may not result in action because they do not sufficiently consider the values of the customers. A more integrative approach is needed to engage stakeholders in the decision making process and to increase the effectiveness of any investment in an energy audit process.

2.1.5 Conclusions

The process of characterizing buildings energy systems for the purpose of recommending upgrades need to be pursued incrementally, based on the perceived likelihood that investments will be made in energy efficiency improvements. For example, Level 1 audits need to be offered at no cost, and should be performed as a mean for securing fee-based energy analysis services. The capability to quickly detect potential energy improvement opportunities through observation and engagement with building owners/occupants are key steps in the first stages of energy retrofit project development. Training programs to build these capabilities including energy audit training will be discussed in a latter section.

2.2 Competency Model for Energy Auditors

The growth of the building energy efficiency field is limited by the availability of a skilled workforce to carry out the work (CBEI n.d.). In the early 1970s, McClelland defined competencies as significant predictors of employee performance and employee success. A competency is an assortment of Knowledge, Skills, Abilities (commonly called KSAs), behaviors, and personal characteristics that encompasses mental, intellectual, cognitive, social, emotional, attitudinal, and
physical aspects necessary for success in a given role, job, or position (Boyatzis 1982; D. C. McClelland 1976). McClelland regarded competency models as an assessment tool that can help to develop behaviorally-based interview protocols; clarify hiring requirements in terms of finding the right fit; equip the staff with complete information regarding succession into specific positions, inform employers about the necessary development strategies; and finally educate potential job seekers to be employable. Competency models are also regarded as an asset for human resources to assist employees, both at entry points into a position and moving up or over to other positions in order to benefit the organization (S. McClelland 1994; Boyatzis 1982). To meet the needs of a high-growth sector such as commercial building energy efficiency, business/industry leaders, educators, trainers, career counsellors, and job seekers, they must understand what competencies are necessary for workplace success. To address these needs, the US Department of Energy (DOE) worked closely with the commercial building industry and other key stakeholders to develop national guidelines to improve the quality and consistency of commercial building workforce and energy-related jobs (CBEI n.d.). One product of this work was Job Task Analysis (JTAs) for four key job titles in the advanced commercial buildings workforce: energy auditor, building commissioning professional, building operations professional, and energy manager. Another outcome of this effort was a competency model for each of the positions (Figure 2.2).
The model is a visual representation of the competencies for an entire industry often represented through illustrations that map competencies in a hierarchical manner (Campion et al. 2011; Cao and Thomas 2013). Levels in the model correlate with the likely arenas in which competencies are cultivated from personal traits developed through life experiences to those learned in training, and onward and upward through increasingly focused work experiences. An industry competency model can serve as a resource to help articulate the workforce needs. The model can be used to understand the competencies required to work in an industry and how they match job requirements with industry recognized skills. The model can also illuminate gaps in competencies in the industries where short-term training programs can be developed to address them or where existing programs can be modified (Ennis 2013). The tiers of the model are divided into blocks representing the skills, knowledge, and abilities essential for successful performance in the industry or occupation represented by the model. Each competency is described by key
behaviors or by examples of the critical work functions or technical content common to the industry.

Every occupation requires a different mix of knowledge, skills, and abilities, and is performed using a variety of activities and tasks. The top tier describes the occupation-specific knowledge, skills, and technical competencies for each of the job titles including Building Operations Professional, Energy Auditor, Building Commissioning Professional, and Energy Manager. For example, building energy auditing can include a wide array of processes and tasks across building systems that are often completed by highly experienced professionals. Table 2.2 is a sampled list of occupation specific competencies for energy auditors, the entire list can be accessed on the Department of Labor website (“Competency Model Clearinghouse - Advanced Commercial Buildings Energy Management,” n.d.).

<table>
<thead>
<tr>
<th>Energy Auditor</th>
<th>Knowledge</th>
<th>Skills</th>
</tr>
</thead>
</table>
|                | • Building physics  
|                | • Building pressurization  
|                | • Minimum required time period of utility data  
|                | • Sampling protocols and procedures  
|                | • Type of energy audits (level 1, 2, or 3, etc.)  
|                | • Typical energy analysis methodologies  
|                | • Typical energy usage by building type  
|                | • Typical Percentage of end usage by occupancy type  | • Understand available data types for weather (bin data, hourly data, TMY, etc.)  
|                |              | • Ability to determine tools needed for an audit  
|                |              | • Ability to interpret thermography  
|                |              | • Programming skills |

The capability to detect potential energy improvement opportunities through observation and engagement with building occupants are key steps in the first stages of building energy characterization. However, the level of competencies required to conduct energy audit levels varies significantly. Table 2.3 shows the training and experience level that can be accomplished by less experiences and even entry-level energy professionals. Competency models can establish the basis
on which instructional designer and curriculum developers ensure that workers are developing the right skills. The up-skilling of building operators has been found to offer a significant opportunity to address no-cost and low-cost energy savings in buildings.

Table 2.3. Foundational Training and Experience Base in Energy Audit Process (Advanced Energy Retrofit (AER) Auditor Competency Map | CBEI, 2012)

<table>
<thead>
<tr>
<th>Level 1 Audit: Walk Through Analysis</th>
<th>Level 3 Audit: Detailed Analysis of Capital – Intensive Modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Foundational Training and Experience Base</strong></td>
<td><strong>Foundational Training and Experience Base</strong></td>
</tr>
<tr>
<td>Technician</td>
<td>Engineer</td>
</tr>
<tr>
<td>Engineer</td>
<td></td>
</tr>
</tbody>
</table>

### 2.3 Student-led Energy Assessment

In the engineering curriculum, a strong emphasis on learning through application can be beneficial to students by developing competencies valuable in the workforce (Leal Filho, Shiel, & Paço, 2016; Lockrey & Bissett Johnson, 2013; Mills & Treagust, 2003; Mote, Dowling, & Zhou, 2016). Further, in programs that are engaging students in building energy assessment, an observation has been made that students of the unique potential engage with building owners as a third party resource and to build trust with building owners (Wu, 2016). Engaging students is also known as a powerful strategy in the pursuit of a sustainable future by other studies (Brundiers, Wiek, & Redman, 2010; Dale & Newman, 2005; Feldbaum, 2009). In an effort to explore ways to engage students in buildings energy assessment, an undergraduate course was developed and first
offered at Penn State in fall 2014. Titled “Leadership in Building Energy Efficiency (LBEE)”, the course focuses on the identification and implementation of no-cost/low-cost energy efficiency measures in buildings, referred to as building re-tuning (BRT) (PNNL n.d.) or a level 1 audit as defined by ASHREA standard (Safari, Riley, Asadi, Delgoshaei, & Shulock, 2016). The training prepares students for a subset of the occupation and industry related tasks for energy auditors (as defined in the ACBW competency model). These efforts have revealed that students are capable of conducting level 1 audits with a reasonable amount of training. A collaborative and innovative workflow is needed to engage trained students in energy retrofit projects in their community. This can be an opportunity to reduce the costs associated with screening audits and will be discussed in the next section.

2.4 Business Development in Energy Retrofit Industry

Engineering firms are regularly confronted with a decision to evaluate the potential benefits and possible drawbacks of new projects. These decisions are complex due to the uncertainties in the business environment work but very important as they have profound effects on the day-to-day operations and the long-term performance of the construction firm (“Decision-Support System for Modeling Bid/No-Bid Decision Problem,” 1990). Research has been conducted to facilitate and support these decision making processes through the use of decision trees and risk analysis methods (De Reyck, Degraeve, & Vandenborre, 2008). Previous studies have also indicated that business professionals, when making a decision with uncertainty, have a tendency to be risk averse (Han, Diekmann, & Ock, 2005). In studies of both novices and experienced industry participants, it has been found that intuition-based decisions were flawed by the complexity of uncertain information
and several biases due to risk aversion. Accordingly, appropriate project selection should rest in how to lessen the risk aversion by the adoption of risk and decision analysis tools.

In practice, the dominant process in which energy efficiency projects are initiated is through regular operation and maintenance programs or through un-solicited proposals by energy services firms (Angela Lewis, 2011). States and electric utilities have had a significant contribution in promoting energy efficiency practices in the United States. For example, many state utility legislations require electric utilities to engage in energy efficiency plans, known as demand-side management (DSM) programs. These programs are often funded by adding small surcharges on electricity sales. In some states, energy efficiency is encouraged by investing in energy efficiency programs in lieu of building new power plants (Steven E. Stoft, 1995). The underlying assumption in these programs is that the energy users respond to cost minimization opportunities such as, low-interest loans, tax credits, and rebates which directly enhance financial incentives on the demand side. In a critique of current demand-side management efforts, low participation rate (the cumulative number of customers participating in a program divided by the number of customers eligible for the program) and the high administrative cost was highlighted as challenges that need to be addressed (Nadel, 1992). Furthermore, while most utilities track direct program costs (e.g., rebates), most do not track indirect costs such as marketing costs and staff time (Berry, 1991). Another drawback of these programs is that they typically focus on targeted types of improvements, like specific equipment replacements, and rarely achieve deep levels of efficiency improvements.

2.5 Project Delivery Methods

Integrated Project Delivery (IPD) is a process that engages all stakeholders in optimizing delivery of Architectural, Engineering and Construction (AEC) projects through following key

- Early involvement of key participants
- Shared risk and reward
- Multiparty contract
- Collaborative decision-making and control
- Liability waivers among key participants
- Jointly developed and validated goals
- Analysis and integration of multiple building systems

These key principles and elements are universally applicable to all building types and projects that involve major building changes. Frequent interactions during the project delivery process necessitates that designers provide numerous iterations of their design documents to other team members for their evaluation and input (“Integrated Project Delivery: A Guide - AIA” 2007). Previous studies have identified the value of integrated forms of project delivery on high performance building projects (Korkmaz, 2005). The use of integrated project delivery, best value contracting, and inclusive open communication strategies on project teams have each been found to contribute directly to the achievement of sustainable goals with the least possible first cost. Conversely, traditional forms of project delivery used on some case study projects, combined with inexperience project teams, have been found to contribute directly to wasteful project results that often result in the stripping of green features from buildings in cost-saving measures. The engagement of specialty contractors (mechanical and electrical) in more integrative delivery and design-build methods has been found to enable improved design integration and more accurate estimating of equipment and construction costs than estimates offered by engineering firms (Riley, McLaughlin, Sanvido, Kerr, & Horman, 2005).
Energy Savings Performance Contracting (ESPC) is another approach to accelerate investment in energy improvement and can be useful for the minority of customers who lack capital budgets. Performance contracting are also useful for utilities who do not want to operate programs on their own (Nadel, 1992). By partnering with an energy service company (ESCO), a facility owner can use an ESPC to pay for today's facility upgrades with tomorrow's energy savings (“Energy Savings Performance Contracting | Department of Energy,” n.d.). The typical process of an ESCO includes (1) Target-specific types of facilities, (2) Identify profitable retrofit “leads”, (3) Develop proposal for financing or a “bankable” project, (4) Secure project financing, and (5) Propose project to building owner that typically requires them to make no capital investment. A key challenge with typical ESCO models includes the pressure for profitability from financing organizations leading to only pursuing “low hanging fruit” as opposed to more integrative and deep energy retrofits, such as the larger customers and the most lucrative energy-saving measures particularly lighting and cogeneration (Nadel, 1992). Current building retrofits are predominantly focused on energy and cost efficiency at an individual building or building component scale (Craft, Ding, Prasad, Partridge, & Else, 2017). Further, once implemented, these projects tend to strip the profitability out of energy efficiency projects in buildings, as remaining improvement with longer payback periods can no longer be bundled with a high rate of return measures.

2.6 Lean and Sustainable Practices

The AEC community has long been aware of deficiencies in the design and construction processes that are evidenced by cost overruns, project delays, and quality and performance shortfalls in the finished construction (Forbes, Ahmed, & Ahmed, 2010). Existing codes and standards adopted by states and municipalities define minimum standards for building energy
performance. In an effort to set more aggressive goals for buildings, multiple green building assessment platforms have been introduced worldwide including but not limited to: BREEAM (United Kingdom), LEED (United States and Canada), DGNB (Germany), Green Star (Australia), Green Mark (Singapore) and CASBEE (Japan). These tools provide a scoring system to quantify a building's environmental impact in categories such as location and site, conservation of water, energy, and materials, and occupant comfort and health (Gou & Xie, 2017). While having proven to be an enormously valuable vehicle for mainstreaming green building technology, these tools are considered by many as incapable of guiding design in a systems-approach manner to address environmental, social and economic concerns (Benne & Mang, 2015; Gou & Xie, 2017).

The Lean Project Delivery System (LPDS) emerged in 2000 from theoretical and practical investigations in the manufacturing and service industries to maximize value and reduce waste in the delivery process. The following points are key characteristics of LPDS (Ballard, 2000):

- Project is structured and managed as a value generating process
- Early involvement of stakeholders to plan and design the project steps through cross functional teams
- Feedback loops are incorporated at every level, dedicated to rapid system adjustment

To implement LPDS successfully, collaboration, early-involvement, aligned incentives, and integration of the project stakeholders is required. The stakeholders involved in a construction project need ample training to enable them to possess the necessary knowledge and expertise in implementing LPDS; In addition, the lengthy LPDS implementation period (for documenting and managing information and discussion meetings) was observed and regarded as a barrier in construction projects (Marhani, Jaapar, Bari, & Zawawi, 2013). The explicit management has been considered a critical part of successful project delivery that needs to be incorporated into future experiments and implementations of LPDS (Glenn Ballard, 2008). An overview of different phases
in a sustainable retrofit project delivery was presented in the work of (Ma et al., 2012) and is shown in Figure 2.3.

![Figure 2.3. Key phases in a sustainable building retrofit program as defined by (Ma et al., 2012)](image)

The use of lean and sustainable practices in project delivery has been examined on AEC projects but needs improvement in every aspect: processes, methods, tools. New forms of contract and unaccustomed roles and responsibilities require a cultural change in the industry.

### 2.7 Regenerative Design and Development

General Systems Theory (GST) introduced by Ludwig von Bertalanffy in 1968, promoted an open system and evolutionary thinking which maintains that complex systems cannot be explored through simple analysis but rather they require a system of thinking that is focused on change, growth and development. This system of thinking challenged the reductionist mode of thinking in western societies. This model set the foundation for living systems science, a mode of thinking developed by Charles Krone; a developmental technology for constantly enhancing the thinking capacity of the systems. Later in the beginning of 1990, living systems became the fundamental concept in regenerative design and the work of John Lyle in sustainable development (Lyle, 1994). The concept of regenerative design requires the integration of human development
with natural systems in a cyclical processes that allows for continuous replacement, renewal and
rebirth (Lyle, 1994). More recently, the Regenesis Collaborative Development Group (Lynn
Birkeland 2014; Du Plessis and Brandon 2015; Mang and Reed 2012; Cole 2012), formalized an
approach for “Regenerative Design and Development” of the built environment.

The concept of regeneration is being tested in a variety of industries and communities. The
developmental processes suggested by the living systems science was later employed and evolved
by businesses. These processes were intended to improve the understanding of interactions between
businesses, communities and nature as living systems and to construct mutually beneficial
relationships between the three through effective integration of industrial, community and natural
processes. To elevate and enrich the conversation about Regeneration and more specifically support
the development of regenerative business practices, and effort has been undertaken to define the
seven “First Principles” of Regeneration. The First Principles of Regeneration offer a theoretical
foundation to engage with the concept of regeneration in a way that examines systems at work and
the design of interventions in systems. The principles are intended to help business leaders move
beyond paradigms of “doing less harm” or “doing good” to a paradigm that is more reflective of
healthy living systems, which are constantly evolving and growing capacity (Benne & Mang, 2015;
Sanford, 2016). The seven “First Principles” of Regenerative Business are summarized in Figure
2.4.
**Wholes**: Capable of operating in a self-determining way within a system and interactively with other systems, Engage others developmental (persons, systems, businesses, industries) as alive, connecting with their lives as a whole, Keeps all individuals focused on their effect on the whole.

**Potential**: Initiating with potential, the intention and effect to be achieved, rather than existing problems and issues. Avoiding generic ideals, focusing on specific individuals, entities, to realize more of that Essence potential.

**Essence**: Exhibiting singularity, working as “one of one” by increasingly bringing forth essence and non-displaceable uniqueness. Understanding Essence provides for a pervasively aligned execution that is focused, distinctiveness and make responsibility a way of doing business.

**Development**: Seeking to grow and develop capacity and capability in each and all entities to realize their essence. Development of critical thinking skills and personal self-determination of function, being and will.

**Nestedness**: Embedded within greater and lesser systems, each playing a core role in the success of the whole and other nested wholes.

**Nodal**: Seeking points for intervention that evoke systemic beneficial effects that have significance to the system. Similar to acupuncture, where a single point or set of points are recognized as most effective for systemic regeneration.

**Reciprocity**: Operating within living dynamic processes, making “fitting” contributions that benefit system health with care for contributions and outcomes for all.

**Figure 2.4. First principles for regeneration**
Current pursuits of “sustainable” or “green” building design can be characterized by a technologically driven mindset that typically considers a building to be a set of components that can be optimized or improved. Regeneration is a new paradigm that redefines the built environment – from the old, building-centric definition to one that includes the relationships between and among buildings, infrastructure and natural systems, as well as the culture, economy and politics of communities (Cole, 2012; Du Plessis & Brandon, 2015; Lynn Birkeland, 2014; Mang & Reed, 2012). Regenerative work explicitly and deeply engages stakeholders in a collaborative and co-creative process that are locally designed for a value-based but safe to fail transformative experiment (Dominique Hes ID, 2018; Reed & 7group (Organization), 2009). Before a regenerative approach becomes widely accepted in the industry a number of challenges need to be overcome including fragmented institutional structures of governance and ownership; the challenge of qualitative and long-term measurability; and economic pressures for scalability and replicability of local solutions (Benne & Mang, 2015).

2.8 Research Questions

Retrofitting small sized commercial buildings is central to meeting sustainability challenges. Over the past few decades, much has been learned about how to structure and promote programs and business practices in this sector. However, a number of problems have also arisen that must be addressed to achieve the full potential of the energy retrofit projects. The first challenge is a perceived need for building a skilled workforce. This has been the subject of significant investment and has included the development of new workforce guidelines, competency models, and training programs focused on building energy efficiency. A collaborative and innovative work flow is needed to engage entry level energy assessors in energy retrofit projects. The second challenge is
the lack of clear process map to pursue small building energy retrofit projects in a more integrative way. New forms of contract and unaccustomed roles and responsibilities require a cultural change in the industry. Regenerative approach to design and development is an emerging concept that engages stakeholders in a collaborative and co-creative process that are locally designed for a value-based but safe to fail transformative experiment. After reviewing the literature and identifying research gaps, here is the research question that forms the design of this research: *How can we evolve the delivery process of energy retrofit projects to reduce systemic risk in business development and increase the social, economic, and environmental benefits of these projects?*
3 Research Design

This Chapter describes the process followed in this research and the logical and developmental steps to pursue the research goal and objectives. An important aspiration of this research effort is to focus on the *potential* of building energy efficiency as opposed to the *problem solving* paradigm that prevails in existing efforts. Focusing solely on solving immediate problems can obscure new, emergent problems that eventually renders old work obsolete. *Potential*, on the other hand, always offers values even as conditions change.

3.1 Research Context

This research represents an extension of a larger effort to explore how to pursue the potential of small commercial building energy efficiency. The Consortium for Building Energy Innovation (CBEI) was established in 2010 by a number of U.S. organizations and departments. CBEI’s mission was to transform the energy efficiency market for small and medium sized (i.e. less than 250,000 square feet) commercial buildings such as office buildings, schools, and hospitals, so that these buildings are retrofitted and operated with low-cost, integrative technologies and innovative practices. To this end, CBEI developed four major focus areas: integrated design, technology packages, portfolio solutions, and workforce development. One outcome of the CBEI included the development of a concept for an entity that could serve both the building energy efficiency education and business development efforts required to pursue small to medium commercial building retrofits. In 2014, Pennsylvania Department of Environmental Protection (PA DEP) funded a collaborative effort designed to demonstrate a regenerative approach to facilitating building energy assessments that leads directly to energy retrofit proposals and installations in small sized commercial facilities. The transactions of that collaboration and resulting energy
assessment/retrofit projects serve as the context for this research, as well as the key sources of data used in the development of the framework.

3.2 Statement of Purpose

The goal of this research is to develop a holistic approach to small commercial building retrofit business development that will contribute to a market-driven expansion resulting economic, ecological, and social systemic effects. A regenerative approach is pursued that seeks to support the evolution of the energy services industry towards value-driven processes and essence contributions of stakeholders. This effort includes the characterization of stakeholders and a value stream map of the energy retrofit process from initial client engagement through measurement and verification. The result of this effort enables the identification of discreet investments made through the process and the evaluation of these investments in terms of risks and potential values observed by stakeholders (Figure 3.1).

**Function:** To create a holistic framework that will support the evolution of the processes used to pursue energy retrofits of small sized commercial buildings

**Being:** In a way that optimizes return on investment risks during the project development process and facilitates value exchange between stakeholders,

**Will:** So that building owners, occupants, designers, builders, manufacturers and policy makers experience systemic economic, environmental, and social system effects of a vibrant and vital energy services industry.

Figure 3.1. Statement of purpose, inspired by the levels of work framework developed by Charlie Krone and published by the Regenesis Group
3.3 Research Process

In this research, case studies of multiple energy retrofit business development efforts are used to develop a process map and identify key decisions that involve significant investment of resources. The case study approach taken in this process first identifies examples and patterns of processes that can be grouped into phases of activities. Case studies were also drawn upon to identify discreet activities and examples of value exchange between stakeholders. The processes, decisions, and value exchanges were used to inform the design of the proposed framework. Case studies were also used to populate and inform the development of risk analysis methods through the quantification of key variables as well as to enable a retrospective analysis of business development processes that successfully resulted in approved retrofit proposals. These cases enabled the framework to adapt risk management methods that are specific to markets, business models, and building types. Another source of data was several focus groups throughout the program period to capture the tacit knowledge of the stakeholders of building retrofit industry, to reveal factors that will reduce risk of investing in project development (or will increase the likelihood of accepting retrofit proposal, and to identify favorable conditions, customers’ expectations and current offerings of co-creators.

3.3.1 Detailed Research Steps

Research objectives and specific tasks that will be carried out in pursuit of the research goal are described below:

1. **Objective: Conduct review of existing industry practices** - to review and evaluate existing industry practices by conducting focus groups and semi structured interviews with experts in energy retrofit industry, in a way that clearly maps project development processes, shows value
exchange between stakeholders, and identifies activating and restraining forces to achieve efficiency goals, so that it can provide a theoretical foundation for proposing the framework.

Tasks:
1.1. Design a semi-structured interview to capture the tacit knowledge of experts in the field
1.2. Map the existing process used for energy retrofit projects delivery
1.3. Characterize different risks in the business development process and different strategies that were adopted by participants of the study

2. **Objective: Framework Development** - Develop a framework to transform the energy retrofit processes for small commercial buildings in a way that (1) aggregates value adding processes, (2) introduces order and organization to these processes, (3) articulates the unique offering of different co-creators so that highlights critical investment decisions, enables the design of strategies and instruments for the evolution of these processes, and facilitate a better exchange of value between different stakeholders

Tasks:
2.1. Define regenerative principles that guided the framework design
2.2. Describe the development process
2.3. Present the framework and describe its attributes

3. **Objective: Evaluate framework** - Assess the framework through focus groups and case studies in a way that characterizes risks and uncertainties in business development processes so that a systemic optimization in return on business development risks can be demonstrated.

Tasks:
3.1. In the context of design, development and delivery of DEP retrofit projects, present examples on how framework can represent discreet lessons learned about the process in terms of key steps and investments of time and energy
3.2. Incorporate risk management techniques to measure the effectiveness of the improved process (analyzing three different cases of DEP projects backward to show value based decision making)

3.3. Highlight the exchange of value between stakeholders and how it can inform decision making in business development process

A summary of the overall research approach is presented in Figure 3.2. Reflective practices were embedded in the project delivery process to support the developmental aspect of regenerative work necessary to evolve the thinking of all the stakeholders involved in the program.

![Figure 3.2. Overall Research Design Using Mixed Methodology](image_url)
4 REVIEW OF INDUSTRY PRACTICES

This section outlines the result of a qualitative study that was designed to review and evaluate different approaches to the development and construction of building energy retrofit projects. Multiple experts in the energy service industry were interviewed to understand existing business models and project delivery methods. Different work processes were mapped and compared to identify opportunities and challenges in achieving deep efficiency goals in smaller projects. Then we focused on the observations that interviewees have made over time about early indicators of successful retrofit construction projects. The investment risks in business development are also presented with a list of management strategies adopted by participants of the study. The results was used as a theoretical foundation for proposing the framework.

4.1 Interview Design

The following are the steps that were followed in the design of the interviews:

4.1.1 Type of Interview

For this research, semi-structured interviews are carried out one to one with an interviewer and interviewee using the telephone. With a semi-structured interview format, the agenda is relatively set, but the interviewer is free to follow the respondent’s train of thought and to explore tangential areas that may arise; the interviewer may rephrase the questions and how they are asked depending on the individual participants and the interviewees can express their viewpoint, without a framework imposed by the researcher (Hashemnezhad, 2015).
4.1.2 Participants for the Study

In qualitative investigation, sampling is usually purposeful in nature. Purposeful sampling involves the researcher selecting potential participants who represent the group to be studied with the aim of talking to a reasonable cross-section of people. For a typical phenomenological study, the total number may be around 10 participants; this differs from theory-testing quantitative research in which random or probability sampling is often used (Frey & Fontana, 1991). For this research, participants with at least five years of experience were selected from the firms that have insight and understanding about design and construction of building energy retrofit projects in the Philadelphia region. The cross section of Firms that should be included in the data collection process includes:

- Firms that perform retrofits of various building sizes and use types in the Philadelphia region
- Firms with different business models from direct-install vendors to full performance contracting
- Firms with different range of value adding process from utility consultation to deep retrofit
- Firms that are completely reliant on state energy programs to those that are focused on ROI

4.1.3 The questions to be asked

The questions were developed after an extensive literature review and after the first year of the DEP program. The interview is designed in four sections, the first section (Section A) includes questions about the company structure and previous experiences in building energy retrofit. This data is used to demonstrate that a diverse set of experience is represented in the interview set including companies that perform retrofits of various sizes and scales and according to the types of business models identified in the framework. It is also helpful to establish the level
of experience of respondents and subsequent credibility of data collected on work processes, early indicators, and risk management.

The next set of questions (Section B) are designed to map the work processes in a retrofit project. This information is used to confirm that each company follows specific steps in project delivery without following a framework for following different value streams. This data is also used to verify the phases of retrofit processes represented in the framework.

Then (in Section C) we focused on the observations that participants have made over time about how small retrofit projects develop and early indicators of successful retrofit / direct installation construction projects. The results are used to improve screening programs and client engagement methods to lower customer acquisition costs. Finally, we captured the variable expenses associated with pursuing projects, time (hours spent) as well as other expenses such as marketing expenses (Section D). This data confirms that client acquisition is viewed as an investment, and that at some point, projects become unviable, and that many companies have no formal way to assess this risk. A template for interview introduction and list of questions is included in appendix A.

4.2 Interview Results

Analysis of interviews usually involves categorizing the data into themes or categories (sometimes referred to as coding) (Basit, 2003). The interviews lasted about an hour each. Recordings of interviews were first transcribed and then coded using NVivo; NVivo which is a qualitative data analysis software tool gives researchers a place to organize, store and retrieve data enabling them to work more efficiently, save time and rigorously back up findings with evidence. The results are summarized below.
**Section A**- Table 4.1 presents the characteristics of the participants of the study, including the role of the interviewee and the profile of their company.

Table 4.1 Cross-section of businesses that were included in interview process

<table>
<thead>
<tr>
<th>Data Categories</th>
<th>Interview No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent has at least 5 years of experience</td>
<td>✓  ✓  ✓  ✓  ✓  ✓  ✓  ✓  ✓  ✓  ✓</td>
</tr>
<tr>
<td>Standalone energy consulting services</td>
<td>✓</td>
</tr>
<tr>
<td>Grant funded energy consulting services</td>
<td>✓</td>
</tr>
<tr>
<td>Energy Efficiency and Sustainability Consulting</td>
<td>✓</td>
</tr>
<tr>
<td>Utility Energy Program</td>
<td>✓</td>
</tr>
<tr>
<td>Turnkey Energy Efficiency Service</td>
<td>✓  ✓  ✓  ✓</td>
</tr>
<tr>
<td>Lighting Contractor</td>
<td>✓</td>
</tr>
<tr>
<td>Mechanical Service Division</td>
<td>✓  ✓  ✓  ✓</td>
</tr>
<tr>
<td>Design-Build Mechanical Contractor</td>
<td>✓  ✓  ✓  ✓</td>
</tr>
<tr>
<td>ESCO Contractor (Performance Contracting)</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Section B**- The work processes of each company were mapped and evaluated to understand different business models and delivery methods in energy retrofit projects. As it’s presented in figure 4.1, each company is unique in terms of the type of activities that they engage in.

*Design-Build Energy Retrofit in Small Commercial Buildings:*

*Turnkey Energy Retrofit in Small Commercial Buildings (Primarily Lighting):*  

<table>
<thead>
<tr>
<th>Marketing</th>
<th>Screening Audit</th>
<th>On-spot Proposal Development</th>
<th>Installation (through trade allies)</th>
<th>Application for Grants</th>
<th>Validation (Survey)</th>
</tr>
</thead>
</table>

Figure 4.1. Engagement in different business development processes
Section C - The results from capturing the observation of interviewees over time yielded a set of key indicators of project success. The following is the list of factors identified by participants of the study that can potentially increase the likelihood of a successful retrofit projects:

1. Clients’ culture (Are they willing to invest in their building)
2. Client turnover (New use or higher expectations of an existing building)
3. Broken or aging energy systems
4. Quick payback saving opportunities (Major lighting upgrade which can be bundled with longer payback upgrades)
5. Square footage size of building (Less saving opportunity in smaller buildings)
6. Ownership status (higher chance of capital investment if the tenant is the owner)
7. Alignment with regional incentives
8. Cooperative clients with trust in the services being offered
9. Concerned clients about the magnitude of electric and gas bills (long operating hours and energy intensive operations)
10. The uptake rate for small commercial business energy efficiency programs is proportional to the amount of grant/subsidy available for the program.

Issues that could filter out prospects included:

1. The disclosure that business had recently purchased extensive amounts of new equipment (implying that historic utility data and costs were irrelevant to current operations and lack of major upgrade opportunity)
2. The disclosure that the business had just opened (implying that 12 months of utility bills were not available and higher likelihood of going out of business)
3. A clear demonstration that client lacked interest in energy savings or retrofit or both (e.g. not sharing utility bills or showing no desire for equipment replacement)
Section D- In this section of interview different risks in business development process were captured and summarized in table 4.2:

<table>
<thead>
<tr>
<th>Sources of Risks</th>
<th>Risk Management Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing- lack of trust</td>
<td>1- Branding</td>
</tr>
<tr>
<td></td>
<td>2- Leveraging testimonial and reviews from former customers (Established credibility)</td>
</tr>
<tr>
<td></td>
<td>3- Leveraging the trusted relationships such as mayor's office- asking them for logo or official letterhead</td>
</tr>
<tr>
<td>Return on marketing investments</td>
<td>1- Client acquisition through service agreements or referral</td>
</tr>
<tr>
<td></td>
<td>2- Tracking the success rate of different marketing strategies</td>
</tr>
<tr>
<td></td>
<td>3- Targeted marketing:</td>
</tr>
<tr>
<td></td>
<td>- In utility programs, accessing the utilities and focusing on higher EUI</td>
</tr>
<tr>
<td></td>
<td>- Focusing on healthy businesses (where you can justify long term payback)</td>
</tr>
<tr>
<td>Smaller projects take almost as much engineering work upfront as a larger project does.</td>
<td>1- Prequalification of potential clients to ensure return on investment</td>
</tr>
<tr>
<td></td>
<td>2- Limiting the pool to 30000sf and 100 kW demand</td>
</tr>
<tr>
<td></td>
<td>3- Access utility data and maintains logs and systems data through pre-assessment surveys before on-site data collection (As part of qualification process)</td>
</tr>
<tr>
<td></td>
<td>4- No data logging and detailed energy simulation</td>
</tr>
<tr>
<td></td>
<td>5- On-spot proposal generation through tablet and automated data collection process</td>
</tr>
<tr>
<td></td>
<td>6- Having reliable network of contractors and material vendors for best pricing on volume work</td>
</tr>
<tr>
<td>The risk of investing in a an investment grade audit without having a contract</td>
<td>1- Having a service contract that makes screening process and access to data possible with no investment.</td>
</tr>
<tr>
<td></td>
<td>2- Differentiating your service from free audits and take a purchase order for audit before engaging</td>
</tr>
<tr>
<td></td>
<td>3- Understating the intent of client and defining the scope of work before investment (To estimate the risk- At least 50% chance that we would have a project in hand)</td>
</tr>
<tr>
<td></td>
<td>4- Engage with client or tenant before designing the solutions to understand the systems, issues, and clients’ need better and avoid the cost of redesign (They are more knowledgeable about the building operating issues)</td>
</tr>
<tr>
<td></td>
<td>5- Hiring intern and entry level auditors when having a robust training program</td>
</tr>
<tr>
<td>The risk and cost of service calls and questions about savings during warranty phase</td>
<td>1- Verification of savings and necessary adjustments are less of a financial burden when we have a mechanical maintenance agreement with the client.</td>
</tr>
<tr>
<td></td>
<td>2- Including the cost in a separate TAB contract (Test, Adjust, Balance)</td>
</tr>
<tr>
<td></td>
<td>3- Installing BAS to access pre and post construction data</td>
</tr>
</tbody>
</table>
4.3 Conclusion

The interview process revealed different challenges and opportunities in pursuing retrofit projects. Each firm is utilizing different strategies to avoid unnecessary investment and risk in business development which has resulted in few engagement in proactive retrofit of smaller buildings. The retrofit of small commercial buildings on a large scale offers a significant opportunity to reduce energy consumption and associated greenhouse gas emissions and economic development in the form of construction activity and energy and utility cost savings for small businesses. Significant factors restrain efforts to pursue small commercial building energy efficiency including limited ability of building owners/tenants to invest in retrofit, lack of information, and limited market capability to develop and aggregate small commercial building retrofit projects. Small to medium commercial building owners and occupants are typically less likely to solicit energy services for many of the reasons such as lack of awareness and capitol. As such, the pursuit of energy efficiency opportunities in these types of buildings typically requires an investment by an energy services company or other entity to engage the facility owner/tenant and ultimately offer a solution that includes a retrofit proposal coupled with financing the limits or eliminates the capital investment of the building owner/occupant. An effort is needed to reconcile the forces that currently result in too few successful projects and high reliance on subsidy programs by municipalities and utilities (Figure 4.2).
Regenerative Strategy:
Holistic approach to energy efficiency in buildings leading to economic development and environmental health.

Activating Force

Potential of Building Energy Effectiveness with collateral benefits of:

- Buildings consume and waste large amounts of energy - money saved could be used for higher value purposes
- Potential exists for “bankable” and job creating construction projects
- Potential for Improved comfort/satisfaction of occupants
- Potential systemic reduction of environmental impacts of buildings

Restraining Force

Disbelief that action is a good investment with different excuses such as:

- Limited resources to capitalize / invest in retrofit
- Expensive to design retrofit solutions
- Expertise to address integrated retrofits design is scarce
- Shared ownership blurs who will invest / benefit
- Interruption to building operation
- Volatility in policies, variable energy programs, and evolving retrofit technologies

Compromise:
ESCO Model, one time retrofit of low hanging fruit that extracts value as opposed to adding value

Figure 4.2. Reconciling around potential, inspired by the law of three framework developed by Charlie Krone and published by the Regenesis Group
5 Framework Development

In this chapter, a framework is proposed for supporting the systematic pursuit of energy retrofit projects in small to medium sized commercial buildings sector as a whole. A regenerative approach is used to explore the key interactions between physical, human and natural systems. The goal of the framework is to support the continuous evolution of energy retrofit industry for small commercial buildings in a way that characterizes the delivery process as a series of calculated investments for aggregated added values, introduces order and organization to the delivery processes, articulates the unique offering of co-creators so that highlights critical investment decisions, enables the design of strategies and instruments for the evolution of these processes, and facilitate a better exchange of value between different stakeholders.

5.1 Design Rationale

Table 5.1 presents the central belief, philosophy, and principles that was built on existing literature and is guiding the design of the framework.

<table>
<thead>
<tr>
<th>Belief</th>
<th>The central belief inspiring this effort is that a regenerative approach to business development is needed in order to continuously study, evaluate, and improve building energy retrofit industry.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophies</td>
<td>The directions taken to explore and pursue this effort are as follows:</td>
</tr>
<tr>
<td></td>
<td>a. A more integrative and holistic approach will yield deeper systems effects and efficiency outcomes.</td>
</tr>
<tr>
<td></td>
<td>b. A granular description of the whole energy retrofit delivery process is needed for the systematic pursuit of energy retrofit projects.</td>
</tr>
<tr>
<td></td>
<td>c. Value stream mapping helps to illustrate the chronological sequence of activities in a business process and to identify the inefficiencies and the non-value adding activities.</td>
</tr>
</tbody>
</table>
The framework is designed in a way that the following principles are met:

1. Identify high impact activities and value adding processes through historic data analysis.
2. Identify key decisions about investments during processes through risk analysis.
3. Facilitate the pursuit of long term energy improvement vs. one-time retrofit through collaborative business models.
4. Generate a measurable, beneficial social or environmental impact in the system alongside a financial return for co-creators.

### 5.2 Development Process

This section describes the activities pursued for the proposed framework development, including (1) articulation of different value streams, (2) a granular description of different phases of building energy retrofit projects, and (3) the use of process modeling to identify the inefficiencies and the value adding activities.

#### 5.2.1 Building Energy Efficiency Value Streams

The variable approaches to improving building energy efficiency in literature and practice can be grouped into four distinctive value streams. The focus of this research on the early phases of project development is intended to help identify the appropriate value stream for a project as soon as possible to avoid wasteful data collection and analysis activities that are not likely to yield value to clients or energy services companies.

**Deep Energy Retrofit:** An integrated upgrade for multiple building systems that is responsive to unique conditions and client/facility needs. Typically includes blend of measures with variable levels of ROI.
**Specialty Retrofit:** Upgrading specific energy systems of a building that is feasible in terms of investment risks. Typically systems are pre-determined based on incentive program targeting lighting, refrigeration, hot water systems etc.

**Re-tuning:** Improving building energy performance through low cost/no cost opportunities. *Intended to empower the business owner to take over the implementation phase and includes DIY measures for lighting and air sealing, adjustment of thermostat schedules, and behavioral changes.*

**Benchmarking:** Measuring building energy consumption over time for the purposes of comparison through established rating programs such as the EPA Benchmarking program (“Benchmarking | ENERGY STAR,” n.d.)

### 5.2.2 Phases of Building Energy Retrofit Projects

The first step in the development of the framework was to define the specific phases of energy retrofit processes. These phases were identified based on previous research on retrofit project delivery and the need to examine discreet steps in the business development process for smaller projects. The criteria used to discern each phase is: 1) the types of processes that could be logically grouped together because of their relationships (e.g. concurrent or prerequisite relationships between activities necessary to offer a specific value), 2) processes that required significant investments of time and energy to undertake, and 3) processes that require different types of capacity (knowledge, skills, experience). The resulting processes for initiating and pursuing energy retrofit projects is summarized in Table 5.2.
Table 5.2 Key Steps in Development of Small Buildings Energy Retrofit projects

<table>
<thead>
<tr>
<th>Project Progress</th>
<th>Short Description</th>
<th>Activities to Perform the Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Lead Generation</td>
<td>Marketing</td>
<td>Utilizing different marketing approaches to find potential candidates</td>
</tr>
<tr>
<td></td>
<td>Outreach</td>
<td>Communicate in person, or via telephone, or e-mail with business owners to find those who are willing to receive an energy retrofit proposal</td>
</tr>
<tr>
<td></td>
<td>Qualification</td>
<td>Collect initial information including utility data to evaluate the alignment of owner/ building condition with the scope of available services</td>
</tr>
<tr>
<td>2- Screening Audit</td>
<td>Data Collection</td>
<td>Collect required building information during site visit and interview with operator / manager of the buildings</td>
</tr>
<tr>
<td></td>
<td>Rough Savings Evaluation</td>
<td>Benchmarking and evaluating saving opportunities using existing templates, databases, and automated tools</td>
</tr>
<tr>
<td>3- Retrofit Design and Planning</td>
<td>Analysis</td>
<td>Define the scope (What is driving project? Economics? Comfort? Function?) Prepare reports containing energy analysis results or recommendations for energy cost savings</td>
</tr>
<tr>
<td></td>
<td>Agreement</td>
<td>Reviewing the proposal with client; Preparing and signing an agreement; Supporting the client with rebate application</td>
</tr>
<tr>
<td>4- Implementation</td>
<td>Act/ Implement</td>
<td>Construction Planning, Procurement (order material/purchase), Implementation, and Commissioning</td>
</tr>
<tr>
<td></td>
<td>Verification</td>
<td>Tracking energy/cost savings to ensure that technical/ financial objectives were reached</td>
</tr>
</tbody>
</table>

The first step in building energy retrofit business development is client engagement. Through different marketing approaches and targeted outreach to business owners, leads are generated. The leads then are contacted to assess the owners’ willingness to invest in their building. As part of qualification, utility data are requested. If the lead is qualified and aligned with the
program, in the next step, detailed building energy related data would be collected on site. Interview with building tenants is a critical element in data collection as it allows for the ongoing observation of occupants to be revealed, for example hot and cold areas of building, poor air quality, and occupancy patterns. This data is then used to understand and benchmark building energy use, identify areas with energy waste, and propose energy conservation measures (ECMs) and retrofit options. Results of this analysis are then communicated to client with recommendations for actions. When accepted, the selected retrofit measures are then implemented through a construction process and commissioning of systems. The final phase is validation and verification of energy savings. This verification step is often essential to the fact that many energy retrofits are financed based on projected energy savings.

5.2.3 Process modeling

This research utilizes process modeling as a means to reveal granular elements of the business development process for small commercial retrofits. This includes the characterization of stakeholders and a value stream mapping of the energy retrofit process from initial client engagement through measurement and verification. The result of this effort enables the identification of discreet investments made through the process and the evaluation of these investments in terms of potential value observed by stakeholders. Discreet processes in each of the phases described in section 3.3.2 were identified through experiences on the first set of DEP projects (Figure 3.4). The following criteria were used to identify processes:

1. Well defined activity with an observable starting point and stopping point, for example: “complete initial site visit.”
2. An activity that included a *specific analysis activity*, for example: “perform utility bill disaggregation.”

3. An activity that *required a decision* about how to move forward with a project and as a result, increase investment in the business development process, for example: “determine if return visit to collect additional data is warranted.”

Business Process Modeling Notation (BPMN) was used to graphically represent the processes involved in a retrofit project. BPMN provides a standard that fills the gap between business models and their implementation. The element sets that were used in this research are presented in Figure 5.1. Flow Objects are events, activities and gateways. Events are either start events, intermediate events or end events. Activities are divided into process, sub-process and tasks and denote the work that is done throughout a retrofit project. Gateways are decision points and are used for determining branching, forking, merging or joining of paths within the process. Sequence Flow defines the execution order of the activities within a process. Swimlanes act as a graphical container for a set of activities taking place in each project phase or investment level. A swim lane diagram, also called a cross functional flow chart, or swim lane process map, is an element used in mapping process workflows. It groups components into a distinct sequence, or lane, in the visual presentation of workflow and process charts. Swimlane diagrams distinguish capabilities, roles, and responsibilities for each sub-process in business process workflows. In this research, the use of swim lanes are utilized to represent variable value streams that can be pursued in the energy retrofit business development process, and as a means to elevate alternative pathways for this process as opposed to a singular focus on energy retrofits.
5.3 Framework design

The framework design is illustrated in Figure 5.2 and combines the retrofit phases described above (Section 5.2.1) in columns of activity and the unique value streams also described above (Section 5.2.3) as swim lanes. In the proposed framework, decisions are made sequentially and the investment level can be adjusted with the acquisition of new information. The pursuit of an energy retrofit project requires a series of investments in business development (cultivation of client) and data acquisition about physical conditions. Decisions to proceed with subsequent steps require an evaluation of the feasibility of the retrofit project and the risk of proceeding. The ideal program would proceed by sorting clients into channels based on their level of enthusiasm and participation. Clients who can provide access to at least one year of their utility bills are qualified from further effort. The utility data was used for benchmarking through EnergyStar Portfolio Manager. After initial qualification, a decision (D1) is made to proceed with on-site data collection. Client’s whose facilities do not show significant potential for effective energy retrofits with double digit projected savings, or who indicate they are unwilling to invest in retrofits, are provided with a streamlined report containing no cost/low cost measures they can take, along with a short list of the most cost-effective retrofit investments they could make if willing. To reduce the risk of investment, entry level employees that are trained for the specific job should be engaged in the processes of delivering this value stream. In this manner, only clients who make it through these
gates and signal their interest in making an energy retrofit investment actually end up receiving retrofit proposals prepared by professional energy service providers. The goal is to minimize ‘wasted’ effort on proposal preparation for clients unlikely to invest.

Key variables in risk assessment would evolve over time with experience in specific target markets. Go/No-Go decisions on further investment in a retrofit project (such as D1 in Figure 5.2) depend not only on the present value of the investment for different stakeholders but also the risk tolerance attitude of decision makers. In the next step of this research, a risk management technique was introduced and deployed to investment decisions of buildings’ energy retrofit. In this approach, decision makers can change the course of the project by deciding whether to defer the investment; abandon, expand, or contract the project; maintain the status quo; and so on. Risk management strategies can be applied to increase the probability of a successful project for all involved beneficiaries.
Figure 5.2 Proposed framework for pursuing retrofit projects
5.3.1 A model for evaluating investment risk

Energy service companies make a series of expenditures sequentially that become profitable only after action is taken and the entire process is completed. Evaluating the project requires a decision support system that determines whether additional investments should be made over the cumulative amount that has already been spent. In valuation of projects that involve contingent decisions, a decision tree can show a strategic road map, depicting alternative decisions, their costs, and their possible outcomes. Figure 5.3 presents the proposed organization of the decision points for evaluating the risk of further investment in a project. Results of project evaluation might lead to: departing from the investment scenario that was originally planned, acceleration or deceleration of investment rate, shifting the project to a less risky but lower value stream, or simply abandoning the project in midstream. This decision is made based on Net Present Value (NPV) of completed project, the remaining investment needed for completion, and the risk and opportunity cost of abandoning or pursuing project completion. In a broad sense, the project value is the net difference between the project revenues and costs over its entire life cycle. If the project’s net revenues during the production phase are higher than the investment costs, the project is considered a worthy of investment.

![Figure 5.3 Model of key decision inputs, outputs, and potential value stream](image)

Figure 5.3 Model of key decision inputs, outputs, and potential value stream
6 Framework Evaluation

In this section the results of case studies and focus groups are used to present the value of the proposed framework in improving business development process. Case studies are first described and then the value exchange between stakeholders is mapped. A systemic optimization in return on business development risks is also demonstrated using DEP project data.

6.1 Case Study

The DEP projects described in Section 3.1 is the main source of data used to design the framework. The goal of these case studies were to penetrate a hard-to-reach market segment: independently owned neighborhood businesses involving food preparation and sales, housed in small commercial buildings: restaurants, pubs, corner stores, sub shops, delicatessens, and bodegas. These buildings utilize substantial amounts of energy for refrigeration, kitchen ventilation, and hot water, in addition to common lighting, HVAC and plug loads. Another source of data was several focus groups with DEP project partners including the Philadelphia Energy Authority (PEA), Pennsylvania State University (Penn State), and Private Energy Partners (PEP) and under the name of Energy Outreach and Assessment Center (EOAC). Figure 6.1 presents the role of the participants in the focus groups.
Figure 6.1 Six focus groups to engage stakeholders in framework development

Figure 6.2 presents the flow of an individual project from initial client engagement, through building energy assessment, energy-economic savings analysis, and retrofit construction. Initially, facility owners and tenants were contacted by EOAC staff (Step 1) and owners that were interested in the offering of the program then were scheduled for a free screening assessment (Step 2). To lower the cost of the screening process, EOAC employed less experienced (entry-level) students that were trained for collecting vital data about building conditions, energy use, and capabilities of building tenants/owners to accommodate energy upgrades. Projects with favorable conditions then received a detailed audit in which upgrades were both identified and priced to create a retrofit plan (Step 3). Next, EOAC staff aligned projects with the variable types of financial instruments that could support upgrades (Step 4). Once approved, the retrofit was completed, and long term energy monitoring were initiated to verify savings and to ensure that financial objectives were reached (Step 5). In this approach business development risks are shared between different partners and each partner is bringing a unite offering to the program.
Table 6.1 presents the number of businesses that were contacted during the program and if they expressed interest in the program. In total, 116 businesses in Philadelphia were contacted and the results were documented in a shared tracking sheet; based on the notes (collected by different recruiters) and the follow-up results 57 businesses were interested in the program and were asked to provide 12-month of their utility bills; businesses that were aligned with the project requirements were scheduled to receive an on-site energy assessment (45 Businesses out of 57 interested clients received a free building energy assessment); 29 of conducted assessments were converted to deep retrofit proposals and during the first year of the program 2 clients completed the construction activity.

Table 6.1 Summary of Program Results

<table>
<thead>
<tr>
<th>Project Development Activity</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student assessors that were trained</td>
<td>10 in Summer 2016</td>
</tr>
<tr>
<td></td>
<td>9 in January 2017</td>
</tr>
<tr>
<td></td>
<td>9 in Summer 2017</td>
</tr>
<tr>
<td>Businesses that were Contacted</td>
<td>116</td>
</tr>
<tr>
<td>Businesses Interested in the Program</td>
<td>57</td>
</tr>
<tr>
<td>Businesses Provided Utility Data</td>
<td>46</td>
</tr>
<tr>
<td>Businesses Received On-site Energy Assessment</td>
<td>45</td>
</tr>
<tr>
<td>Businesses Received Retrofit Proposal</td>
<td>29</td>
</tr>
<tr>
<td>Businesses Implemented a Deep Retrofit</td>
<td>2</td>
</tr>
</tbody>
</table>
6.2 Application of Risk Management

A value-adding process the framework is intended to address is the characterization of the energy retrofit ecosystem in a way that enables the identification and evaluation of strategies to evolve process with the goal of making overall positive system effects, in particular the reduction of risk. Specifically, strategies that reduce investment costs and process waste can be examined to increase the present value of investments. The following strategies have been proposed and tested in the context of DEP project:

6.2.1 Reveal Key Decision Points

Probability of project viability can be increased by designing decision points in the process at critical stages of project to avoid high risk investments.

Purpose: To guide the projects in the right value stream as early as possible, by asking key questions that avoid investment waste and reveal existing potentials, so that, the risk taken is aligned with project potential.

Criteria for identifying key decision points:

- Prior to large investment in data collection and energy saving/ economic analysis
- Immediate after any analysis that reveals critical information for decisions

The results from focus groups yielded a set of key indicators of project success as presented in Table 6.2. Based on the results from focus groups, the project team developed a set of client screening questions that would more quickly assess the likelihood of a retrofit project. After quantifying the likelihood of a project, Net Present Value (NPV) of the completed project can be calculated based on the remaining investment needed for completion and the expected outcome using the following equation (Strategy and Analysis in Using Net Present Value, 2005).
NPV = Success Likelihood \times Payoff + Failure Likelihood \times Remaining Investment

Table 6.2 Evaluation of retrofit likelihood

<table>
<thead>
<tr>
<th>Process ID</th>
<th>Short Description</th>
<th>Criteria/ Questions</th>
<th>Score</th>
<th>Importance</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Fit for Assessment?</td>
<td>- In-operation more than 1 year?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- What are the operating hours?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Is owner cooperative?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Is it owner occupied?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Eligible to apply for regional incentives?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td>Fit for Retrofit Proposal?</td>
<td>- Have walk-in refrigeration units?</td>
<td>Yes/No?</td>
<td>Saving Opportunities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Have high utility cost?*</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Have linear fluorescent fixtures installed and not LEDs?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Have old HVAC equipment (&gt;20 years or beyond end of life)?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Is owner willing to invest in a building retrofit project?</td>
<td>Yes/No?</td>
<td>Client's Willingness</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td>Fit for Deep Retrofit?</td>
<td>- Multi systems upgrade with savings more than 25%?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Owner approves technical and financial proposals?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Availability of incentives, capital or financing mechanism?</td>
<td>Yes/No?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Monthly aggregate utility bills of $1000 - $1500 were often cited as a burden (Few participating clients had utility bills lower than this level.)

Since there is uncertainty in input variables, a common practice is to conduct a sensitivity analysis by varying these variables to study their impact on the final NPV. A Monte Carlo simulation was used in the following example to generate possible future scenarios (or market conditions). The results for net value of the project for each probable market condition are plotted.
on a histogram from which the value at risk can be determined. Figure 6.3 presents two typical pathways that emerged through evaluation of case studies.

<table>
<thead>
<tr>
<th>Scenario (1)</th>
<th>Retrofit Likelihood: 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV: (negative) - $1050</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario (2)</th>
<th>Retrofit Likelihood: 90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV: (positive) $1350</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6.3. NPV for two different scenarios at a decision point

**Scenario (1):** If the project was not favorable for investing in screening level and project valuation resulted in a negative NPV (in cases that retrofit likelihood is low for example when the business owner is unlikely to be interested in investing in energy retrofit) a decision was made to move the project in to a benchmarking value stream and perhaps pursuing the use of EPA Portfolio Manager.

**Scenario (2):** If initial screening efforts revealed a high potential for a retrofit and the project NPV was favorable for investing in preparing deep retrofit proposal, a decision was made to invest in detailed technical and financial analysis. Identification of different investment levels based on indicators of project success ensure that each set of activities will result in predefined values and will facilitate the pursuit of long term energy improvement vs one-time retrofit. The next section explains the rational for determination of these indicators.
6.2.2 Targeted outreach (utilizing crowdsourced and publicly available data)

Uncertainty about project outcomes can be minimized by asking the right questions at the right time in the process. Through case study projects key investment decisions have been identified in the process to allow for application of risk management techniques. In this section a screening method is proposed to facilitate development of small construction projects in a targeted region. This was done by predicting decision making behavior of business owners based on their restaurants’ attributes in social media and the publicly available neighborhood information. This enables the energy retrofit industry co-creators to find viable businesses for financed energy efficiency projects by screening the whole market and prioritize the targets for recruitment.

When viewed as a business opportunity, energy retrofit projects represent a unique segment of the building design and construction market in that they are most commonly pursued through a marketing and engagement method as opposed to the solicitation of services by a building owner or client. Like any other construction projects, time and money would be invested to recruit a project and a portion of this investment is expected to be wasted as a price for increasing business development activities and hitting a higher rate of success. In the DEP program, lead generation activities were pursued in a way that ensures an effective marketing approach through continuous improvement of its processes and services to better meet current and future customer needs. Figure 6.4 shows the process map that was followed. The target market can be identified through research and by accumulating results of market analysis over time (P1). The continuous market research throughout the program has been undertaken through the assessment of patterns on projects that eventually led to the development of retrofit proposals. To identify patterns, two methods are employed: (1) several focus groups over the program period with project team members who played roles in identifying clients, collecting data, authoring reports and proposals, and ultimately managing retrofit projects and (2) statistical analysis to identify the factors contributing to
successful projects. To set up a project, potential candidates then should be engaged in a conversation about the offerings of this program (P2) and if they showed interest and willingness, they need to be qualified (P3) for the program requirements. The qualification process is designed to ensure that leads are aligned with the type of services that are being offered. Before conducting an on-site assessment (P5) and more investment in project development, a decision point (D1) is designed to assess the likelihood that a project matures into a retrofit project. This critical evaluation and the resulting Go/No-Go decision improves the screening programs and client engagement methods to lower customer acquisition costs. Collected information might lead to departing from the investment scenario that was originally planned, acceleration or deceleration of investment rate, or simply abandoning the project in midstream. This decision is made based on the risk and opportunity cost of abandoning or pursuing project completion.

![Figure 6.4 Process Map for Effective Lead Generation (First Step in Business Development)](image)

By evaluating patterns in the data collection, analysis and decision-making patterns of clients, a series of key decision points emerged. These points serve as checkpoints in the process in which the likelihood of a retrofit project is evaluated and the project path can be shifted into a more appropriate value stream. In an effort to explore alternate methods to identify likely retrofit projects, an extensive data-mining research effort was completed in December 2018 that sought to
identify patterns in YELP ratings between restaurants with highly favorable conditions for retrofits. There are 2260 food services listed on the Yelp website in the city of Philadelphia. Yelp is a local-search service powered by crowd-sourced forum where businesses can obtain reviews from a large, open and rapidly-evolving group of internet users. Yelp data from restaurants and corner stores in this study was extracted on 9/5/2017 and was analyzed to examine different variables such as popularity (Star Rating and No. of Reviews), total operating hours, food culture, business category, etc. Neighborhood socioeconomic and demographic was another variable included in this study. Mean income, mean age and a population density of the neighborhoods where the restaurant is located was extracted from Esri’s Tapestry on 9/17/2017. Then statistical data analysis was performed to determine whether significant relationships exist between the customer characterization variables according to Yelp and Tapestry listed in Table 6.3 and the response variable; Go/No-Go decision to invest in on-site data collection.

The raw data includes 116 observations of eleven (11) variables with one (1) response variable. The response variable in this analysis is the decision to proceed with a free on-site energy assessment to the business (Go), or to abandon the project (No-Go). Some restaurants were not listed on Yelp and do not have records on the following six (6) variables: No. of reviews, star ratings, price range, total operating hours, ambiance and alcohol sale status. It was decided to remove the 22 restaurants unlisted on Yelp resulting in a reduced sample size of 94 observations. Another issue is that more than 20% of observations have missing values in ambience, price range, and alcohol sale. While it is believed that these variables could be valuable in identifying restaurants with favorable retrofit conditions, they were not included in the statistical analysis.
Table 6.3 Summary of Variable of Interests

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Variable (D1)</td>
<td>0 – No-Go, 1 - Go</td>
<td>Go/No-Go decision to invest in on-site data collection</td>
</tr>
<tr>
<td>Neighborhood- Mean Income (K)</td>
<td>14,000 to 94,000</td>
<td>Provided through census (“ZIP Lookup</td>
</tr>
<tr>
<td>Neighborhood- Mean Age</td>
<td>23.70 to 46.50</td>
<td></td>
</tr>
<tr>
<td>Neighborhood- Population Density</td>
<td>1648 to 33364</td>
<td></td>
</tr>
<tr>
<td>Business Status on Yelp</td>
<td>0 - Not Listed, 1 - Unclaimed, 2 - Claimed</td>
<td>Status of whether a restaurant has claimed their Yelp account, not claimed or has it unlisted.</td>
</tr>
<tr>
<td>No. of Reviews on Yelp</td>
<td>1 to 2227</td>
<td>How many reviews the restaurant has on Yelp.</td>
</tr>
<tr>
<td>Star Rating on Yelp</td>
<td>2 to 5</td>
<td>A number of stars on Yelp. 1 is bad and 5 is best</td>
</tr>
<tr>
<td>Price range on Yelp</td>
<td>1 to 3</td>
<td>1 $= under $10, 2 $$= $11-$30, 3 $$$= $31-$60</td>
</tr>
<tr>
<td>Total Operating Hours (per week)</td>
<td>18 to 112</td>
<td>How many hours the restaurant is open per week</td>
</tr>
<tr>
<td>Ambience</td>
<td>0 - Casual, 1 - Hipster, 2 - Trendy, 3 - Classy, 4 - Romantic, 5 - Divey, 6 - Intimate</td>
<td>How Yelp classifies a specific restaurant.</td>
</tr>
<tr>
<td>Alcohol Availability (Yelp)</td>
<td>0 - No, 1 - Yes</td>
<td>Whether a restaurant has no alcohol available (0), beer and wine available or a full bar (1)</td>
</tr>
</tbody>
</table>

Logistic regression has been widely used for describing and testing hypotheses about relationships between a categorical response variable and one or more predictor variables (Peng, Lee, & Ingersoll, 2002). In this study a logistic regression model is used to test if the probability of the occurrence of the event, in which a restaurant is highly likely to mature into a retrofit project, could be modeled based on the restaurants’ attributes on the internet. Binary logistic regression was
performed to fit a model to the dataset using Minitab and results are shown below. The model is based on 94 events, each with a variable indicating the final Go/No-Go decision and the following predictors: the mean income, mean age, population density in the neighborhood, number of reviews, star rating, and total operating hours. In logistic regression, the response variable, which in this study is the Go/No-Go decision for each project lead, is represented by a variable Y. An arbitrary code value, 1, was used to categorize highly likely candidates that received an on-site energy assessment (Go) and, 0, when it was risky to invest more in pursuing the lead (No-Go). The resulting fitted model (Equation 1) can be applied to new data to give an estimate of the probability of \( Y=1 \) for that observation using equation 1. Confidence intervals are a function of the standard errors of the estimated regression coefficients and a specified probability level of 95% to show uncertainty in regression. The parameters of the fitted model are given in Table 6.4, with \( \chi^2 \) values for testing the significance of the individual terms. Two highly significant predictors (\( p<0.05 \) and marked by * in the table 4) are No. of Reviews with a negative coefficient and operating hours with a positive coefficient in the equation.

Equation 1: \( Y'=-2.94 + 0.0151 \text{ neighborhood- Mean Income (K)} \)
\( -0.0271 \text{ neighborhood- Mean Age} + 0.000043 \text{ neighborhood- Population Densit} \)
\( -0.00261 \text{ No. of Reviews} + 0.175 \text{ Star Rating} + 0.0227 \text{ Total Operating Hours} \)

Equation 2: \( P(Y=1)=\frac{\exp(Y')}{(1 + \exp(Y'))} \)

Table 6.4 Summary of Logistic Model for Retrofit Potential

<table>
<thead>
<tr>
<th>Continuous Predictors</th>
<th>Coef</th>
<th>SE Coef.</th>
<th>( \chi^2 )</th>
<th>Significance</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighborhood- Mean Income (K)</td>
<td>0.0151</td>
<td>0.0202</td>
<td>0.56</td>
<td>0.454</td>
<td>(0.9759, 1.0561)</td>
</tr>
<tr>
<td>Neighborhood- Mean Age</td>
<td>-0.0271</td>
<td>0.0671</td>
<td>0.16</td>
<td>0.686</td>
<td>(0.8533, 1.1102)</td>
</tr>
<tr>
<td>Neighborhood- Population Density</td>
<td>0.000043</td>
<td>0.000031</td>
<td>2</td>
<td>0.158</td>
<td>(1.0000, 1.0001)</td>
</tr>
<tr>
<td>No. of Reviews on Yelp</td>
<td>-0.00261</td>
<td>0.0014</td>
<td>5.3</td>
<td>*0.021</td>
<td>(0.9947, 1.0001)</td>
</tr>
<tr>
<td>Star Rating on Yelp</td>
<td>0.175</td>
<td>0.471</td>
<td>0.14</td>
<td>0.71</td>
<td>(0.4727, 3.0005)</td>
</tr>
<tr>
<td>Total Operating Hours</td>
<td>0.0227</td>
<td>0.0107</td>
<td>5.18</td>
<td>*0.023</td>
<td>(1.0018, 1.0446)</td>
</tr>
</tbody>
</table>

Before drawing conclusions based on the analysis above, overall performance of the fitted model should be measured by goodness-of-fit tests. Table 6.5 shows the results of three different
Goodness-of-fit tests from Minitab output. Pearson chi-square goodness-of-fit test and the
deviance goodness-of-fit test (analogous to the multiple linear regression lack-of-fit F-test) require
replicated data (multiple observations with the same values for all the predictors). Since there is no
replicated data for the data set of this study, the deviance and Pearson goodness-of-fit tests are
invalid, so the first two rows of this table should be ignored. However, the Hosmer-Lemeshow test
does not require replicated data so we can interpret its high p-value as indicating no evidence of
lack-of-fit.

<table>
<thead>
<tr>
<th>Test</th>
<th>DF</th>
<th>$\chi^2$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviance</td>
<td>87</td>
<td>112.19</td>
<td>0.036</td>
</tr>
<tr>
<td>Pearson</td>
<td>87</td>
<td>93.2</td>
<td>0.305</td>
</tr>
<tr>
<td>Hosmer-Lemeshow</td>
<td>8</td>
<td>4.81</td>
<td>0.778</td>
</tr>
</tbody>
</table>

This methodology could be broadly applied in the future as additional data accumulates. In
the limited data sample, restaurants with longer operating hours surfaced as the highest indicator
of retrofit feasibility in YELP data. Using this screening methods can improve the business
development process by identifying different factors that could possibly influence the owner’s
decision for investing in energy performance improvement.

6.2.3 Reduce Investment

Project cost can be minimized by the three following interventions in the delivery process:

- Minimizing energy audit cost by engaging trained students and entry level auditors

  The initial screening energy audit can be delivered in a low cost approach and in a manner that
  is aligned with emerging energy and sustainability programs in colleges and universities.

  Through research and experimentation, this collaborative approach led to the development of
a curriculum, an audit process model, data collection tools, and reporting tools that enable college students to deliver retrofit-related information and resources to building owners or energy service providers.

- Supporting the documentation process by providing data collection and report/proposal writing tools (automation and information technology)

An automated report writing tool can add a variety of value to the process of energy assessment including (fadaei, 2016):
- Reduce time required to prepare report
- Ongoing Learning of Users
- Enhanced interaction with homeowners
- Support preparation of report by entry level users

- Data-driven integrated delivery – instrumentation for both the design and verification phases to justify the cost of additional data collection, if needed.

Including instrumentation in the energy management system enables designers to optimize control protocols for the building and, in turn, learn how the controls are affected by future building system upgrades. The two primary reasons for including instrumentation is that it allows (1) more reliable identification of energy savings and demand-reduction measures (involving equipment, operation, and/or control changes) in an existing building and (2) increased confidence in the monitoring and verification process once these measures are implemented (Agami, 2006).
6.3 Value exchange between stakeholders

In a regenerative business model, the value-adding processes contributed and received by stakeholders is sought to be balanced through reciprocal exchanges in a system (Sanford, 2011). To discern and organize different players in energy retrofit projects, in this section stakeholders are introduced. According to (Sanford, 2011) customer or consumer is the first and foundational stakeholder. The second stakeholder, co-creators, refer to the people and organizations who contribute to the creation of a product or service, from raw material suppliers to employees and contractors. The third stakeholder is Earth systems, the original source and infrastructure without which human activities would be impossible (sun, wind, water) and in some cases referred to as ecosystem services. The fourth stakeholder is community, the human inhabitants of all those places with which a business needs to partner in order to source its materials and workers, manufacture its goods, sell its products or services, and recycle or store its waste. The fifth stakeholder is the investor, without which the company’s business would be difficult or impossible to realize. Drawing from Sanford’s work, the five stakeholder groups of the building energy retrofit industry are presented in Table 6.6.
Table 6.6 Stakeholders of Buildings’ Energy Retrofit Industry

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>Building Owner/ Manager; Occupants/Tenants; Building operators</td>
</tr>
<tr>
<td>Co-creators</td>
<td>Energy Service Companies; service providers; contractors; Learning Communities (growing networks of trainers, trainees, and researchers who are interested and work in this area, learning from each other’s experience); Supply Chain Partners</td>
</tr>
<tr>
<td>Earth Systems</td>
<td>Living systems are often under represented members of stakeholder groups. Including them here allows us to honor the fact that buildings and the environment exchange energy and resources on a daily basis and will allow us to think about the long term sustainability of the whole system.</td>
</tr>
<tr>
<td>Investors</td>
<td>Energy investment funds; Building Owners, Business Development Professionals; Utility Companies (ACT 129)</td>
</tr>
<tr>
<td>Community</td>
<td>Neighborhoods; Energy Campaign of Utility Companies; Municipalities; Energy Authorities; Association of Specialty Organizations/Businesses; Community Economic Development Associations</td>
</tr>
</tbody>
</table>

One result from focus groups was ensuring a reciprocal value exchange and a balanced contribution in the network of stakeholders. Figure 6.5 presents the added value for different stakeholders that was observed and captured by project team members.
Figure 6.5. Value Exchange between Building Energy Stakeholders
7 CONCLUSION

Small sized buildings are typically unserved by the energy retrofit industry due to the lack of owners’ ability to manage and finance energy efficiency improvements. In the case of energy-intensive and low-margin types of commercial buildings such as restaurants, the potential for energy savings is high, but the favorable conditions that enable retrofits, such as a pending renovation, propensity of clients to conserve energy, and willingness to take time for a retrofit are scarce. This research examines the potential of building energy effectiveness through the lens of a regenerative paradigm by highlighting following principles:

- View buildings energy retrofit industry as nested systems
- Focus on uniqueness of each project
- Collaborative approach: unique contribution of stakeholder
- Elevate the potential of economic, ecological, and social systems
- Identify nodal interventions to maximize the ROI
- Develop capacity by continuous learning practices
- Pursue continuous evolution in building energy retrofit industry

An assessment of the multiple related organizations as wholes is used to reveal systems contributions and reciprocal value exchange in the process of pursuing energy retrofit projects. In doing so, unique opportunities for organizations and individuals to make contributions was identified and cultivated. Process mapping and the definition of value streams was used to reveal opportunities to organize pursuit of projects as a series of calculated investments to pursue projects based on an evaluation of the potential for a return on investment. The present value of investment at any time period can dictate the navigation between different value streams. The evaluation of strategies to reduce the level of investment required to develop retrofit projects is also enabled by this approach. Strategies with high potential to yield systems effects includes: (1) the integration
of education and training programs that engage students in the performance of screening assessment, (2) investments in integrative delivery methods and information systems for retrofit projects, and (3) integration of assessment methods and measurement and verification activities. The use of risk management methods to guide business development methods in energy retrofit projects can help guide investments in business development efforts by quantifying likely project outcomes.

7.1 Results and Contributions

The specific contributions of this research is described below:

- **Developed a framework for supporting business development process in small commercial building energy retrofits that:**
  - Identifies value adding process
  - Elevates key decisions and their subsequent likely value streams
  - Organizes different processes into a series of calculated investments through the entire value chain of business development
  - Facilitates the application of risk analysis techniques to support investment decision making process under uncertainty about project outcome
  - Enables more collaborative and interdisciplinary pursuits of these investments
7.2 Limitations of research

It is envisioned that future research in energy retrofit project business development and retrofit project evaluation will benefit from the framework by advancing quantitative methods for the evaluation of business development investments in this important sector of the construction industry. While the expected value of the framework is intended to support the pursuit of energy efficiency in buildings of all types and sizes, the immediate results of this research includes the limited extent to which the development and testing of the framework are confined to small sized buildings in the region of Philadelphia. The adaptation of a broadly accessible training program is key to the implementation of this framework in each region. Initial efforts have been made to make the Building Energy Leadership training program accessible and adaptable including multiple offerings of the course in different settings and timeframes. However, additional work is needed to enable this element of the framework to be feasible.
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Appendix A

Energy Efficiency Retrofits of Restaurants and Convenience Stores
A Research Program of Penn State (PSU) and PA Department of Environmental Protection (DEP)

Purpose of interview:
To reveal factors that will reduce risk of investing in project development (or will increase the likelihood of accepting retrofit proposal); In a way that captures the tacit knowledge of the stakeholders of building retrofit industry, identifies favorable conditions, reveals customers’ expectations and current offerings of co-creators; So that we can facilitate the exchange of high quality data between co-creators of retrofit projects

Introduction Script:
This research is motivated by an interest in broadly expanding energy efficiency efforts in Philadelphia with an emphasis on the challenging aspects of small food stores and restaurants and other energy-intensive, low profit margin businesses. Our goal is to help advance these types of projects and create positive economic, environmental, and social benefits.
In pursuit of this goal, we are developing and testing new methods to address small business energy efficiency through a variety of techniques, including workforce development, business practices, and collaborative partnerships.
We are currently interested in learning from your experience to inform methods used to pursue deeper retrofits. Specifically, we are interested in learning key indicators that determine what types of strategies should be pursued on a project, and how these indicators can be determined as early as possible in the project development process.
This interview is designed in four sections, the first section is questions about your company structure and previous experiences in building energy retrofit. The next set of questions are designed to map your work processes. Then we will focus on your observations over time about how small retrofit projects develop and early indicators of successful retrofit / direct installation construction projects. Finally, we are interested in documenting the variable expenses associated with pursuing projects, time (hours spent) as well as other expenses such as marketing expenses.

Part A - Background:
1. What is your role in the company in terms of the design and construction of retrofits?
2. On what types of buildings do you perform energy audits?
3. What proportion of your portfolio belongs to small-medium sized commercial buildings?
4. What is your business model / main source of revenue?
5. What is your organization structure?
6. What is the main source of your project leads? For example, do you work with utilities or municipal programs, or directly with business owners?
Part B - Process Questions

Thanks for sharing your background, now I will switch gears and ask about your work processes:

Please describe your process from initial data collection all the way through verifying savings and financial performance? In other words what process do you follow for developing a project starting with client engagement?

Follow up is needed to make sure client engagement, data collection, design, construction, and saving verification processes are described in details.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client acquisition</td>
<td>What method do you use for customer acquisition? For example, radio hours, billboards, canvassing? Do you track success of different strategies? Who is involved in the process? Experience level? In-house/subcontract? What percentage of prospective clients/leads ask for a retrofit proposal?</td>
</tr>
<tr>
<td>Data collection</td>
<td>How long it takes to complete the data collection process?</td>
</tr>
<tr>
<td></td>
<td>How many times you visit the building?</td>
</tr>
<tr>
<td></td>
<td>How do you access utility data?</td>
</tr>
<tr>
<td></td>
<td>Do you have different strategies for different building conditions?</td>
</tr>
<tr>
<td></td>
<td>Is your data collection process and reporting digitalized or paper based?</td>
</tr>
<tr>
<td></td>
<td>When and why did you realized the need for automation?</td>
</tr>
<tr>
<td></td>
<td>How much time are you saving in project development process as a result of automation?</td>
</tr>
<tr>
<td>Proposal Development Costs</td>
<td>How long it takes to analysis data and design a solution to report? What is included in the report? Who in involved in the process? When do you ask for business owner’s input about the retrofit design?</td>
</tr>
<tr>
<td>Administration Costs for financial services</td>
<td>How much time do you spend to complete grant, rebate and loan applications?</td>
</tr>
<tr>
<td>Project Construction</td>
<td>How long is typical retrofit construction phases? What is your role during construction?</td>
</tr>
<tr>
<td></td>
<td>Do you subcontract certain type of retrofit measures (e.g. refrigeration) if so how do you supervise their work and verify commissioning of those measures?</td>
</tr>
<tr>
<td>Post-retrofit Energy Savings</td>
<td>Are you involved in tracking energy savings of projects?</td>
</tr>
<tr>
<td>Verification</td>
<td></td>
</tr>
</tbody>
</table>

Part C - Indicators of successful project proposal / retrofit

We are seeking access to experts that can share observations they have made over time about how small retrofit projects develop and early indicators of successful retrofit / direct installation construction projects. The results will be used to improve screening programs and client engagement methods to lower customer acquisition costs.

1. As you pursue clients / retrofits, how do you rank the following indicators in predicting if a retrofit project is likely to happen (from most important to least important)? Are there any other indicators that you have observed over time for example?
a. High energy utilization index (based on energy bills)?
b. Aging systems? What types?
c. Specific building type?
d. Business owners’ world view/ personality
e. Financial situation?
f. Ownership status?

2. At what point in the project cycle do you evaluate the specific situation of the client with respect to the indicators listed above? (e.g. During interview? After assessment?)

3. What are the most common explanations offered by clients for not wanting to move forward with a retrofit proposal?

Part D - Costs of Business Development (Client acquisition costs)

We are developing a methodology to apply risk management to the management of a portfolio of energy retrofit projects. This effort would benefit from more detailed estimates of the variable expenses associated with pursuing projects. The next set of questions will focus on how you are tracking different type of expenses you incur on projects. We are interested in time (hours spent) as well as other expenses such as marketing expenses.

1. Is your service fee dependent on project performance? When are you paid for your service?

2. Below are different type of investments in effort to complete and deliver a retrofit project. Please estimate the effort required for each phase of a typical project in the table below.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Hours / project</th>
<th>Other expenses / services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Cost of investments made in engagement and data collection / #proposals requested)</td>
</tr>
<tr>
<td>Client acquisition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Info. Tech / Automation (development cost, maintenance, training)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposal Development Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration Costs for financial services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Supervision / Construction Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-retrofit Energy Savings Verification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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CAREER ASPIRATION: Contribute my unique capabilities toward the continuous evolution of how humans grow the capacity of healthy social, economic, and ecological systems in a way that elevates the consciousness of our diverse communities and challenges me to grow as a person.

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Project Engineer, Abadan Fishery Port, Arvand River, Abadan, Iran, (2009-2012)
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Project Engineer, Asaluyeh Fabrication Yard Project, Bushehr Province, Iran, (2009-2010)
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Project Supervision Engineer, Construction Supervision of Morvarid Multifunctional Harbor Bushehr, Kharg Island and Genaveh, Iran, (2009-2010)

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Creating a Business: A Bootcamp for Science Entrepreneurs 2017
UNECE Global Sustainability Practice 2017