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TARGET-SETTING PRACTICE FOR LOANS FOR COMMERCIAL ENERGY-RETROFIT PROJECTS

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ABSTRACT

Overcoming the financial barriers to energy-efficiency (EE) investments requires efforts to explicitly evaluate energy-related risks during the commercial loan underwriting. To support such efforts, the objective of this paper is to suggest a novel target-setting practice that borrowers and lenders collaboratively can use during the early stages of an energy-retrofit project. The practice uses a simulation called Energy Retrofit Loan Analysis Model (ERLAM) to determine the target-building performance and the allowable cost for design and construction. Using a case study of an energy-retrofit project, this paper demonstrates use of ERLAM by evaluating the impact of two identified energy-related uncertainties (project-cost risk and operational-practice risk) on the financial performance of the investment. This target-setting practice can help project parties gain greater understanding and early confidence in the feasible size- and terms of a loan before moving to design

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development. As a result, the practice can support commercial underwriting by helping to overcome financial barriers to energy-retrofit projects.

CE DATABASE SUBJECT HEADINGS

Case studies; Commercial buildings; Energy efficiency; Financing; Lean Construction; Risk management; Simulation

INTRODUCTION

Overcoming the financial barriers to energy-efficiency (EE) investments must be preceded by a robust analysis that addresses energy-related risks inherent in such investments. To improve the effectiveness of the analysis, we suggest that the borrower and the lender start collaborating during the early stages of a project, before design development, to increase their joint understanding about specific types of energy-related risks. Such understanding is crucial for overcoming the said financial barriers. To support such collaboration, we present an analytical exercise to evaluate the financial impact of EE investments while considering their specific uncertainties. While we focus on EE investments for energy retrofits, we do not intend to preclude our approach from applying to new construction as well.

Our premise is that early collaboration between project owners (borrowers) and their lender(s) (represented by underwriters and appraisers) can help to develop confidence needed to determine loan terms for their EE investments that are more favorable than may otherwise be the case (Lee et al. 2012a; 2012b).

Lenders generate loan terms based on project-specific contextual factors such as energy-related systems of the property, and on a business case developed using their criteria to assess EE investments. Borrowers could use early feedback from lenders to determine their allowable cost for design and construction, based on the available loan size.

To support the collaboration, this paper introduces a target-setting practice, implemented in a model called Energy Retrofit Loan Analysis Model (ERLAM) that is based on Life Cycle Cost Analysis (LCCA) and Monte Carlo Simulation. We used data from lenders as well as from energy-simulation models to determine input variables and parameters for ERLAM.

To test ERLAM, we used data from a case study of an energy-retrofit project in a Northern California office building that was funded by a construction loan and completed in 2011. At completion, the building owner settled on a 15-year loan with a local commercial lender to 'take out' the construction loan.

ERLAM uses as input two reducible uncertainties associated with the case project: (1) the project-cost risk and (2) the operational-practice risk. Then, ERLAM computes their impact on the financial performance of the given 15-year loan, and outputs: (1) the target-building performance of the building; and (2) the allowable cost of the project based on the target.

BACKGROUND

We wanted to conduct research, motivated by the well-recognized impact EE can have in the built environment, yet recognizing that, when it comes to financing EE improvements, a significant gap exists between public- and private commercial-building sectors.

ENERGY EFFICIENCY INVESTMENTS IN COMMERCIAL BUILDINGS

The US Department of Energy (DOE) (2009) reported that in 2006 energy consumption in buildings was responsible for 39% of the US primary energy consumption, nearly 50% of which was used by commercial buildings. Thus, energy savings within the commercial-building sector can significantly reduce energy consumption in the US.

Given this recognition, the US president announced the ‘Better Building Initiatives’ targeting to improve EE in commercial buildings by 20% by 2020; these initiatives include nearly $4 billion investment in the public- and private sector (The White House 2011). Similarly, DOE (2010) recently launched its ‘Net-Zero Energy Commercial Building Initiative’ to develop marketable commercial buildings that produce as much energy as they consume over their entire lifecycle. These initiatives indicate the current demand for improving EE in commercial buildings. Interest appears to be rising both in the public- and private sectors in developing EE investments in light of their long-term benefits.

FINANCIAL BARRIERS IN PRIVATE COMMERCIAL BUILDINGS

Despite the increased interests in EE and the initiatives led by the US government, investing in EE improvements in the private sector appears to be hampered by various market barriers.

IBEF's (2011) survey revealed that in the US, 'lack of available capital for investment in projects' accounted for 38% of market barriers, followed by 'inability of projects to meet the organization's financial payback criteria' at 21%, and 'lack of certainty that promised savings will be achieved' at 10%. The survey indicated that US-based organizations, more than organizations in other countries, notably pointed out financing as their biggest barrier.

First, an owner's desire to invest in lifecycle values is constrained by fear of high initial costs, despite the potential lifecycle returns (Ashworth 1993; Ballard and Rybkowski 2009; Cole and Sterner 2000). The perceived cost of energy-efficiency measures (EEMs) can make it difficult to validate a project business case, regardless of the long-term advantages of a higher-value design over a code-minimum design.

Second, Torcellini et al. (2004) measured the actual energy savings achieved by six buildings, intended to be of high performance, and compared these operational savings to their corresponding design goals. In every building, energy savings fell short of their targets. Current gaps in knowledge about EEMs cause building owners to question whether implemented EEMs will perform as intended and whether users/staff will be able to operate and maintain the building as intended (Choi 2009). This questioning makes it difficult for owners to justify upfront investments required to pursue sustainability goals.

Last, the nature of commercial loan underwriting makes EE investments subject to other critical factors including the credit-worthiness of the borrower and the inclusion of recourse (Muldavin 2010; Palmer et al. 2012). However, they are not part of the scope of the study.

RISK IN ENERGY-EFFICIENCY INVESTMENTS

Risk in EE investments, stemming from numerous uncertainties, often makes it difficult for developers to obtain viable loans for their projects. A number of studies discussed risk in EE investments, and specifically financial risk (e.g., Galuppo and Tu 2010; Jackson 2009; Marsh 2009). This suggests that the main driver for such investments may not be 'green ideology' (Muldavin 2010): EE investments can be understood from the perspective of investors and developers looking for attractive financial returns (Melaver and Mueller 2008).

The commercial building industry appears to see risk of EE (retrofit) investments in two ways:

1. Project-cost risk: the level of investment needed to fund the design and construction of the (retrofit) project, and
2. Performance risk: the level of performance achieved after design and construction of the (retrofit) project, required to create positive cash flow.

EE investments are subject to various uncertainties that must be considered during the loan underwriting process. These uncertainties fall into two categories: (1) reducible uncertainties and (2) irreducible uncertainties (Table 1). Both categories can be simulated to determine their impact on the financial performance of an investment using a stochastic model. One can run such models a large number of times in order for its simulation results to have statistically-meaningful confidence intervals.

However, with lack of depth in LCCA and simulation, practitioners tend to allocate buffers in the process of designing and estimating the cost of a project in order to absorb the impact of uncertainties (Table 1). Failure to manage uncertainties can result in a greater contingency used by estimators, and greater-than-necessary safety factors used by designers. This produces overly conservative designs and estimates, thereby raising the funding barrier when applying for a construction loan (Lee et al. 2012b).

<Table 1 goes here>

LOAN UNDERWRITING FOR ENERGY-EFFICIENCY INVESTMENTS

We conducted over 30 semi-structured interviews of 30 minutes to 2 hours long. Interviewees included a range of US-based companies and organizations involved in the development of commercial buildings. The objectives of the interviews included learning how current commercial-loan underwriting is done for EE investments in commercial-building developments, retrofits, and operations.

We learned from the interviews that for capital improvements (incl. energy retrofits) in the commercial sector, a loan as debt capital is the conventional method of financing to raise initial capital for the improvements. Loan payments are made over time using increased Net Operating Income (NOI) realized presumably by lower expenses (lower utility bills) and/or higher income (higher rents) thanks to the EE investment.

When lenders conduct cost-effectiveness analyses of an energy retrofit in the process of underwriting loans, they evaluate: (1) the initial cost and (2) the operation and maintenance (O&M) costs over a loan period:

- Initial cost refers to the initial investments, commonly expressed as incremental costs compared to the baseline (typically designed to meet minimum code requirements)
- O&M costs include energy costs over a target period (e.g., 10 or 15 years).

The initial investment to fund an energy retrofit is usually rolled over into a long-term commercial loan at the project's completion, with a typical loan period of 10 to 15 years.

The loan underwriting process consists of lenders preparing documents in order to determine if a specific loan meets their investment- and risk criteria. Underwriters are vetting: (1) whether or not to extend a loan, and (2) the cost of borrowing based on risk evaluations.

Lenders focus on assessing risks. A metric used in commercial loan underwriting is NOI of the property. NOI is calculated as gross revenue minus operating expenses, with the latter including energy costs. Using this metric, underwriting then involves evaluating the debt service coverage ratio (DSCR) and the loan to value ratio (LTVR) (Muldavin 2010). These ratios are important in assessing risk of a deal, because borrowers are assumed to be increasingly likely to default on their mortgage payments as the DSCR and LTVR approach 1.

- The probability of default is indicated by the DSCR:

$$\text{DSCR} = \frac{\text{Net Operating Income [\$/year]}}{\text{Loan Payment [\$/year]}} \qquad \text{(Equation 1)}$$

- The severity of losses in the event of default is indicated by the LTVR:

$$\text{LTVR [\%]} = \frac{\text{Loan Balance [\$]}}{\text{Appraised Value of Property [\$]}} \qquad \text{(Equation 2)}$$

The DSCR is a particularly important ratio during underwriting, because the net savings from EE investments determine the DSCR in terms of the difference between NOI increase and loan payments. The net saving is a buffer (Figure 1) to absorb impact of variation, stemming from the building-performance risk, especially if the NOI increase were to fall short of what is expected. It also drives the calculation of DSCR to be used in the loan underwriting process (Lee et al. 2012b). In other words, if the target NOI increase is not achieved, the buffer acts to absorb its impact so that the borrower can continue to make loan payments. If the NOI increase is smaller than the loan payment (i.e., the buffer is used up), the borrower will likely have difficulty making loan payments.

<Figure 1 goes here>

Lenders have ‘risk rating’ systems that use both DSCR and LTVR. The risk rating is an indicator of default risk that underwriters have to determine for loan terms. For example, the risk rating determines a capitalization (cap) rate, a conversion factor to determine the value of a property based on its NOI.

$$\text{Appraised Value} = \frac{\text{Net Operating Income [\$/year]}}{\text{Cap Rate [\%]}} \qquad \text{(Equation 3)}$$

The risk rating gets shown on the front page of the proposal presented to the lender's credit committee that makes the final decision on the loan application (i.e., they dis/approve the loan terms).

In the following sections, we explain how DSCR and LTVR lead to determining the cost of borrowing in an energy-retrofit case in our ERLAM model.

DESCRIPTION OF ENERGY RETROFIT LOAN ANALYSIS MODEL (ERLAM)

We used two types of reducible uncertainties as input variables for ERLAM: (1) the project-cost risk and (2) the operational-practice risk (Figure 2). For simplicity, the two variables are assumed to be independent of each other.

<Figure 2 goes here>

Input parameters for ERLAM include interest rates, cap rates, a loan period, and a discount rate. For the case project, we set the loan period equal to 15 years—which corresponds to the actual loan period determined for the project—and assumed a discount rate of 5% for NPV calculations, considering the very low level of current mortgage rates (the cost of borrowing). Risk ratings based on evaluating LTVR and DSCR determine interest rates and cap rates. Learning from a few trials that 5,000 runs would produce narrow confidence intervals for the simulation, we determined to have ERLAM set to run 5,000 samples.

The output of ERLAM is the NPV of realized net savings from the investment, and its sensitivity to the input variables. The net savings represent the impact of the two uncertainties on the building owner's ability to make loan payments, and accordingly determine the viability of the loan. In other words, when the NOI increase falls short of what is expected, the net savings must absorb its impact so the borrower can continue to make loan payments.

CASE DATA OF AN ENERGY-RETROFIT PROJECT

To illustrate and test the use of ERLAM, we use an energy retrofit completed in 2011. The owner of a Northern California office building (the Owner, hereinafter) developed their business case based on an energy audit they had performed in 2008. The audit recommended four potential EEMs, with costs and benefits as summarized in Table 2.

<Table 2 goes here>

Simple Payback (SP) disregards discounting and disregards cash flows once the payback period has been reached, yet it is a widely-used metric that enables project teams to screen out solutions at early stages. Using SP, it didn't take long for the Owner to decide to implement the lighting upgrades (EEMs 1 and 2 in Table 2) because they would have a SP period of 3 years or shorter.

EEM 3 referred to the full replacement of the rooftop packaged air-conditioning units with higher-efficiency units. The audit suggested that EEM 3 would have a slightly longer SP period than EEM 4. However, due to other 'hassle' factors (e.g., disruptions to the existing tenants), EEM 3 was selected for implementation on a total of seven buildings.

In the case study simulation, we used data from one of these seven buildings (Building A, hereinafter). The size of Building A is 2,848 m^2. The initial project cost for the HVAC upgrade was estimated at \$160,330. After a number of change orders, the project completed at \$239,502. The expected NOI increase would stem from utility and maintenance savings, and was expected to be \$29,402/year. After deducting loan payments (15-year amortization at 6.5%) of \$25,032/year, the Owner would supposedly be able to reap net savings of \$4,370/year.

PROJECT-COST RISK

We assumed PERT-Beta as the probability density function (PDF) for the project-cost risk (note that users of ERLAM will have to select the PDF of input parameters). We set the high end of the range to be +50%, and the low end of the range to be -20%. That is, the minimum of the PDF is set at \$128,264, -20% of the initial cost estimate, and the maximum at \$240,495, +50% of the initial cost estimate. We considered the initial cost estimate to be the mode of the PDF. This range from -20% to +50% is wide enough to conduct a sensitivity analysis of the project-cost risk.

We used a total of 8 scenarios (from -20% to +50%, in 10% increments) to conduct a sensitivity analysis of the project-cost risk on the NPV of the net savings. Each scenario has different loan sizes. Each scenario therefore leads to different LTVRs and DSCRs, because the formula for LTVR contains the loan size in the numerator, whereas the formula for DSCR contains loan payments in the denominator.

OPERATIONAL-PRACTICE RISK

The operational-practice risk can be based on energy-simulation models or historical data. Given that simulation is commonly used to evaluate options for design decision making (Mathew et al. 2012), the EnergyPlus energy simulation software was used to determine the ranges of the operational-practice risk of different individual operational measures. Research collaborators in our interdisciplinary research group developed a total of 13 operational measures based on three (large, medium, small) DOE commercial building benchmark models (DOE 2011) for major cities in the US. Then, they calculated the upper and lower boundaries of the operational-practice risk. Based on the characteristics of Building A, and results of the medium benchmark model (4,892 m^2) in the climate of Northern California, we selected 5 applicable measures out of the 13 measures for ERLAM (Table 3).

<Table 3 goes here>

Based on the simulation data (Table 3), we assumed that the operational-practice risk has the following range:

- 15% less consumption as ‘good practice’
- 0% (no deviation from the intended energy saving) as ‘average practice’
- 25% more consumption as ‘poor practice’

‘Good practice’ represents an optimal performance of the building. For ‘average practice’ and ‘poor practice,’ the building has the capability to run at a ‘good practice’ level, but runs less efficiently due to poorer facility management or unanticipated building uses.

Per the recommendation of the research collaborators, we used lognormal as the PDF for the operational-practice risk. We considered ‘good practice’ to be the 5th percentile, ‘average practice’ to be the mean, and ‘poor’ practice to be the 95th percentile (PERT-Beta might have been another choice to model this PDF, but we did not investigate this further). We used a total of 9 scenarios (from -15% to +25%, in 5% increments) to conduct a sensitivity analysis of the operational-practice risk on the NPV of the net savings.

INTEREST RATES AND CAPITALIZATION RATES

To test ERLAM, we used one lender’s risk ratings that govern their loan interest rates and cap rates. This lender’s rating system uses a scale of 1 to 7, with ‘3’ representing a strong and attractive deal while ‘4’ representing an acceptable deal (Table 4). To represent the impact of risk ratings, we assumed the rating of ‘3.5’ as input to ERLAM. Table 4 shows interest rates and cap rates in accordance with given risk ratings.

<Table 4 goes here>

An example computation follows (for the scenario of Column -20%); the steps are:

1. Using the expected loan size = (1 – 20%) × \$160,330 = \$128,264, and the NOI increase of \$29,402/year

2. Assume a risk rating of 3 as the starting point for iteration and look up the corresponding values in Table 4 for the interest rate = 5.5% and cap rate = 6%
3. Compute the loan payment:
    - A = P (A/P, i, n) = \$128,264 × (A/P, 5.5%, 15 years) = \$128,264 × 0.09805 = \$12,576/year
4. Compute the appraised value of Building A:
    - Appraised value = NOI increase / cap rate = \$29,402 / 6% = \$490,033
5. Accordingly the LTVR = loan size / appraised value = \$128,264 / \$490,033 = 26.17%
6. And, the DSCR = NOI increase / annual loan payment = \$29,406 / \$12,576 = 2.34
7. Use Table 4 for the computed LTVR and the DSCR to look up the risk rating and the corresponding interest rate offered and the cap rate applied. Based on the LTVR of 26.17% and the DSCR of 2.34, the risk rating of ‘3’ is selected, and the interest rate of 5.5% and the cap rate of 6%, which are assumed (step 2), are now confirmed.

One can perform the same computation for other scenarios. If the computed LTVR (step 5) and the DSCR (step 6) lead to a different risk rating (step 7) than the one assumed (step 2), then one must look up the new risk rating in Table 4 and find the corresponding interest rate offered and the cap rate applied. One then repeats the computation to confirm the selected interest and cap rate.

Table 5 tabulates LTVRs, DSCRs, and risk ratings based on the 8 scenarios of the project-cost risk and their risk ratings.

<Table 5 goes here>

Table 5 shows that as the project cost increases, the lender will increase the risk rating, which in turn means the lender applies a higher cap rate and interest rate. Accordingly, project-cost overruns not only increase the required loan size, but also increase the cost of borrowing. Thus, the increased likelihood of project-cost overruns will make the business case for the HVAC upgrade increasingly less attractive (note that the borrower will eventually be responsible for any cost overruns during construction).

SIMULATION RESULTS

Simulation results from ERLAM include a sensitivity analysis of the two input variables to the output, i.e., the NPV of the net savings. The sensitivity analysis can be translated to determine the target-building performance and the allowable cost in order to support the target-setting practice.

SENSITIVITY ANALYSIS OF PROJECT-COST RISK TO NET PRESENT VALUE OF NET SAVINGS

Figure 3 presents the simulation result to analyze the sensitivity of the project-cost variable on NPV. It shows that as the project cost increases, the NPV of the net savings decreases. At the same time, the loan-default rate increases: smaller net savings make it increasingly difficult for the borrower to make loan payments. For example, a 20% cost underrun implies a 1.5% default rate. This 1.5% is the area under the PDF that represents the NPV of the net savings for the values smaller than \$0 in Figure 3. Indeed, the loan-default rate is defined as the likelihood that the Owner cannot make loan payments with realized energy savings (i.e., likelihood that NPV of net savings is negative). Likewise, a 50% cost overrun implies a significantly increased default rate of 23.7%.

<Figure 3 goes here>

SENSITIVITY ANALYSIS OF OPERATIONAL-PRACTICE RISK TO NET PRESENT VALUE OF NET SAVINGS

Figure 4 presents the simulation result to analyze the sensitivity of the operational practice on the NPV. It shows that the default rate can remain around 0% as long as Building A consumes less than 5% over the anticipated consumption. However, a default rate of around 100% occurs should Building A consume 15% or more of the anticipated consumption.

The sensitivity analysis of the operational-practice risk shows a significantly steeper decrease of the NPV and much narrower spread than the project-cost risk. Thus, from Figures 3 and 4, one can conclude that the NPV of the net savings is more sensitive to the operational-practice risk than to the project-cost risk.

In retrospect, it is logical that the operational-practice risk has more impact on the NPV than the project-cost risk has. The operation and maintenance costs for the life of a commercial office building is estimated to be about five times greater than the design and construction costs (Evans et al. 1998). This finding emphasizes the importance of building-performance management relative to project-cost management, though both are important.

<Figure 4 goes here>

DETERMINING THE TARGET BUILDING PERFORMANCE

The findings from the sensitivity analysis inform setting the target building performance. If one assumes that the borrower and lender want a low default risk (note that different borrowers and lenders use different risk evaluation criteria), then the target building performance has to be set at a maximum of 5% of the energy-consumption rate (the abscissa of Figure 4), because at that point the default rate is no longer around 0% (as it was for the energy-consumption rate up to 5%), but begins to increase (± some variation that is not shown here). Given the parameters of the lognormal distribution we used to characterize the operational-practice risk, the 5% mark falls at the 75th percentile of the distribution.

DETERMINING THE ALLOWABLE COST

Setting the allowable cost involves translating the target building performance to NPV calculations. When the energy consumption rate in the operational-practice risk increases, the NPV of the net savings decreases.

Setting the target building performance at 5% means that performance at the upper 25% is inacceptable. Accordingly, the lower 25th percentile of the distribution of the NPV of the net savings should be unacceptable as well. Therefore, the analysis sets the allowable cost boundary at the 25th percentile of the NPV calculations (Figure 3).

If Building A performs better than the target building performance of 5%, the lender has the assurance that the Owner will have sufficient net savings to make loan payments ('viability zone' in Figure 3). That is true up to the point where the project cost reaches $225,000, where the allowable cost boundary line crosses the zero NPV line. So, the analysis concludes that the allowable cost should be set at $225,000.

Returning to the facts of the case study on which we based this simulation, the Owner was granted a loan of $239,502 for its HVAC upgrade of Building A. Had the energy-related uncertainties been assumed and tested, and the findings from the energy simulations applied, the results from ERLAM could be interpreted to challenge the viability of the original loan. To make the business case more viable, the project cost could have been more carefully managed.

CONCLUSIONS AND FUTURE RESEARCH

People working in the commercial-building industry have begun to see that investing in EE improvements can yield attractive financial returns, yet investment still requires a robust evaluation of energy-related risks in order to effectively overcome the financial barriers to EE investments. In response, this paper suggested a target-setting practice to determine the target building performance and the allowable cost by evaluating two energy-related uncertainties: (1) project-cost risk, and (2) operational-practice risk. Using an energy-retrofit case in a Northern California office building, the paper demonstrated use of a simulation model called ERLAM to determine the impact of the uncertainties on the financial performance of the investment.

The analysis implies that lenders and borrowers have to carefully evaluate various types of energy-related uncertainties. Commercial lenders must be able to effectively finance energy retrofits, and borrowers and lenders must start collaborating from the early stages of project development onward. In that regard, the target-setting practice can help project parties gain greater understandings of feasible loan sizes and terms before moving to design development. We think that this practice supports commercial underwriting by lowering financial barriers.

We acknowledge that the study presented in this paper has its limitations. The study did not consider factors in commercial-loan underwriting such as the creditworthiness of the borrower or the inclusion of recourse. We suggest that additional studies be conducted to further expand the use of ERLAM in different types of commercial loans for energy retrofits.

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REFERENCES

Ashworth, A. (1993). “How life cycle costing could have improved existing costing.” *Life Cycle Costing for Construction*, J. W. Bull, ed., Blackie Academic & Professional, 119-134.

Ballard, G., and Rybkowski, Z. K. (2009). “Overcoming the hurdle of first cost: Action research in target costing.” *Proc. 2009 Construction Research Congress*, ASCE, Seattle, WA, 1038-1047.

Choi, C. (2009). “Removing market barriers to green development: Principles and action projects to promote widespread adoption of green development practices.” *Journal of Sustainable Real Estate*, 1(1), 107-138.

Cole, R. J., and Sterner, E. (2000). “Reconciling theory and practice of life-cycle costing.” *Building Research & Information*, 28(5/6), 368-375.

DOE (2009). “2009 Buildings energy data book.” US Department of Energy (DOE), Washington, DC.

DOE (2010). “Net-Zero energy commercial building initiative.” <http://www1.eere.energy.gov/buildings/commercial_initiative/index.html> (visited May 4, 2010).

DOE (2011). "Commercial reference buildings." <http://www1.eere.energy.gov/buildings/commercial/ref_buildings.html > (visited April 30, 2011).

Evans, R., Haryott, R., Haste, N., and Jones, A. (1998). "The long term costs of owning and using buildings." Royal Academy of Engineering, London, UK.

Galuppo, L. A., and Tu, C. (2010). "Capital markets and sustainable real estate: What are the perceived risks and barriers?" *Journal of Sustainable Real Estate*, 2(1), 143-159.

IBEF (2011). "Energy efficiency indicator: Global results." Institute for Building Energy Efficiency (IBEF), Washington, DC.

Jackson, J. (2009). "How risky are sustainable real estate projects? An evaluation of LEED and ENERGY STAR development options." *Journal of Sustainable Real Estate*, 1(1), 91-106.

Lee, H. W., Tommelein, I. D., and Ballard, G. (2012a). "Developing a Target Value Design protocol for commercial energy retrofits – PART 1." *Proc. 2012 Construction Research Congress*, ASCE, West Lafayette, IN, 1710-1719.

Lee, H. W., Tommelein, I. D., and Ballard, G. (2012b). "Developing a Target Value Design protocol for commercial energy retrofits – PART 2." *Proc. 2012 Construction Research*

Congress, ASCE, West Lafayette, IN, 1720-1729.

Marsh (2009). “Green building: Assessing the risks - Feedback from the construction industry.” Marsh & McLennan Companies, New York, NY.

Mathew, P., Pang, X., and Wang, L. (2012). “Determining energy use volatility for commercial mortgage valuation.” Lawrence Berkeley National Laboratory, Berkeley, CA.

Melaver, M., and Mueller, P. (2008). *The green building bottom line: The real cost of sustainable building*, McGraw-Hill Professional, New York, NY.

Muldavin, S. (2010). *Value beyond cost savings: How to underwrite sustainable properties*, Green Building Finance Consortium, San Rafael, CA.

Palmer, K., Walls, M., and Gerarden, T. (2012). “Borrowing to save energy: An assessment of energy-efficiency financing programs.” Resources for the Future, Washington, DC.

The White House (2011). “President Obama’s plan to win the future by making American businesses more energy efficient through the “Better Buildings Initiative”.” <http://www.whitehouse.gov/the-press-office/2011/02/03/president-obama-s-plan-win-future-making-american-businesses-more-energy> (visited May 15, 2011).

Torcellini, P. A., Deru, M., Griffith, B., Long, N., Pless, S., Judkoff, R., and Crawley, D. B.

(2004). “Lessons learned from field evaluation of six high-performance buildings.” *ACEEE Summer Study on Energy Efficiency in Buildings*, Pacific Grove, CA, 1-13.

Table 1: Types of Uncertainty vs. Buffer in EE Investments (Adapted from Table 2 in Lee et al. 2012b)

Uncertainty	**Buffer**
Reducible Uncertainty	
Project cost	Cost contingency in design and construction cost estimate
System performance	Safety factor in design
Operational practice	Safety factor in design (commonly ignored)
Irreducible Uncertainty	
Weather	Safety factor in design (commonly ignored)
Energy price	No buffer assumed in design or construction cost estimate
Vacancy rate	No buffer assumed in design or construction cost estimate

Table 2: Recommended EEMs (Adapted from the 2008 Audit Report Courtesy of the Owner)

Energy Efficiency Measures		Energy Savings and Cost Savings			CO2 savings (tons of CO2 per year)	Implementation Costs			
		Estimated Demand Savings (kW)	Estimated Energy Saving (kWh)	Estimated Annual Utility Savings		Estimated Construction Costs	Estimated Potential Municipal Incentives	Estimated Net Costs after Incentives	Simple Payback Period (yrs)
EEM 1	Improve lighting fixture efficiency	61.2	230,808	$32,775	60.5	$110,489	($11,540)	$98,948	3.0
EEM 2	Install lighting controls	0.0	84505	$12,000	22.1	$36,176	($5,334)	$30,842	2.6
EEM 3	Upgrade rooftop HVAC units	226.0	241,000	$34,235	63.1	$424,450	($2,320)	$422,130	12.3
EEM 4	Convert to central chilled water plant	507.8	1,063,000	$151,005	278.5	$1,868,762	($68,000)	$1,800,762	11.9

Table 3: Operational Practice Uncertainties of Selected Operation Measures (Adapted from Table 5 in Lee et al. 2012b)

Operational Practice Measures	**Good Practice vs. Average Practice**	**Poor Practice vs. Average Practice**
HVAC equipment operation schedule	-0.08%	0.23%
Night setback	-0.51%	0.04%
Room setpoints for occupied hour	-3.41%	7.51%
Lighting load control	-6.09%	9.08%
Supply air temperature reset	-0.18%	9.76%
Total	-10.27%	26.62%

Table 4: Interest Rates and Cap Rates by Risk Ratings (Adapted from Table 1 in Lee et al. 2012b)

LTVR of Deal	**DSCR of Deal**	**Risk Rating**	**Interest Rate Offered (15-year Loan)**	**Cap Rate Applied**
30% to 40%	1.8 to 3	**3 (strong)**	5.5%	6%
40% to 50%	1.5 to 1.8	**3.5**	6.0%	7%
50% to 60%	1.25 to 1.5	**4 (acceptable)**	6.5%	8%

Table 5

Table 5: Tabulation by Risk Ratings

Cost Overrun/Underrun Rates	-20%	-10%	0%	10%	20%	30%	40%	50%
Loan Size (Project Cost)	$128,264	$144,297	$160,330	$176,363	$192,396	$208,462	$224,462	$240,495
LTVR	26.17%	29.45%	32.72%	41.99%	45.81%	56.72%	61.07%	65.44%
DSCR	2.34	2.08	1.87	1.65	1.51	1.35	1.25	1.17
Risk Ratings	**3**	**3**	**3**	**3.5**	**3.5**	**4**	**4**	**4**

Figure 1

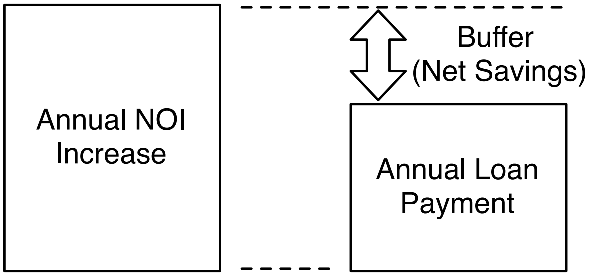

Annual NOI Increase
Buffer (Net Savings)
Annual Loan Payment

Figure 2

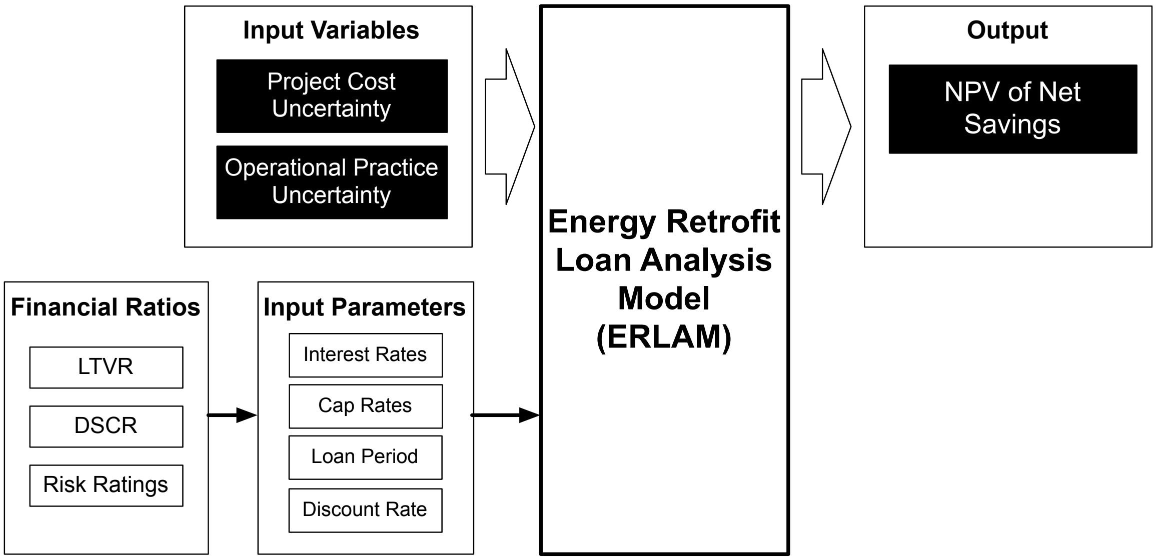

Input Variables
Project Cost Uncertainty
Operational Practice Uncertainty
Energy Retrofit Loan Analysis Model (ERLAM)
Output
NPV of Net Savings
Financial Ratios
LTVR
DSCR
Risk Ratings
Input Parameters
Interest Rates
Cap Rates
Loan Period
Discount Rate

Figure 3

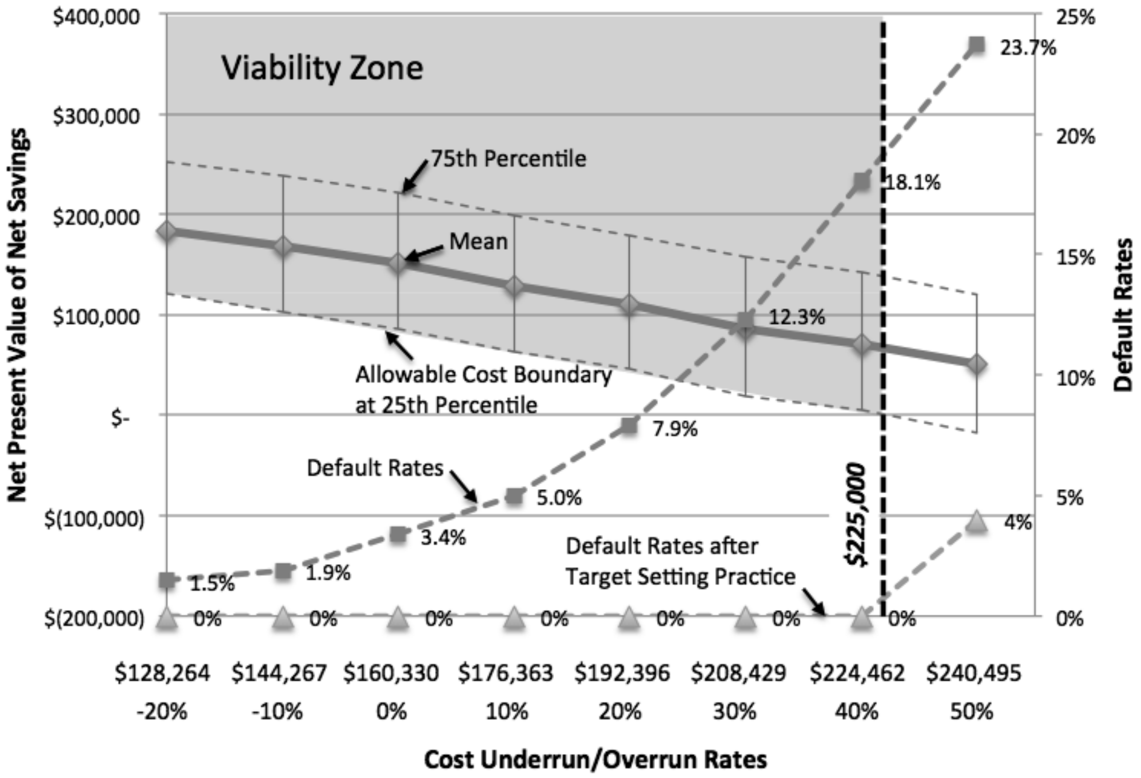
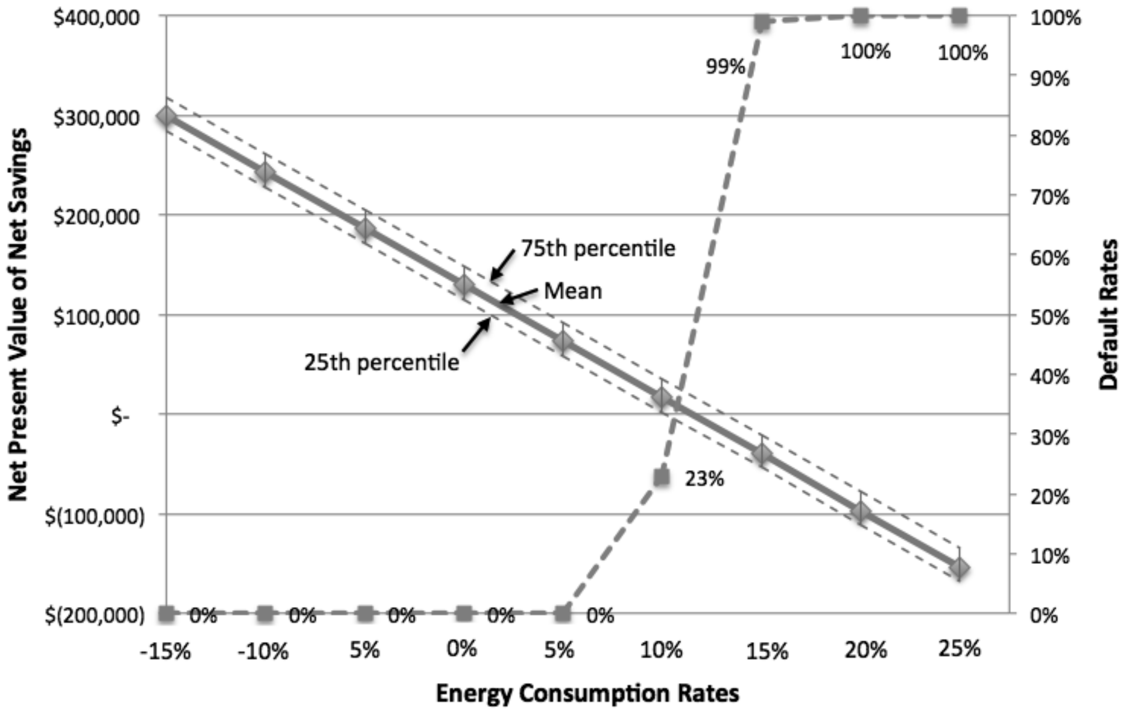

Viability Zone
75th Percentile
Mean
Allowable Cost Boundary at 25th Percentile
Default Rates
Default Rates after Target Setting Practice
$225,000
Net Present Value of Net Savings
$400,000
$300,000
$200,000
$100,000
$-
$(100,000)
$(200,000)
Default Rates
25%
20%
15%
10%
5%
0%
23.7%
18.1%
12.3%
7.9%
5.0%
3.4%
1.9%
1.5%
4%
0%
0%
0%
0%
0%
0%
0%
0%
$128,264
$144,267
$160,330
$176,363
$192,396
$208,429
$224,462
$240,495
-20%
-10%
0%
10%
20%
30%
40%
50%
Cost Underrun/Overrun Rates

Figure 4


$400,000
$300,000
$200,000
$100,000
$-
$(100,000)
$(200,000)
Net Present Value of Net Savings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Default Rates
-15%
-10%
5%
0%
5%
10%
15%
20%
25%
Energy Consumption Rates
75th percentile
Mean
25th percentile
0%
0%
0%
0%
0%
23%
99%
100%
100%

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