



Lawrence Berkeley National Laboratory

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New results and implications for energy efficiency investments

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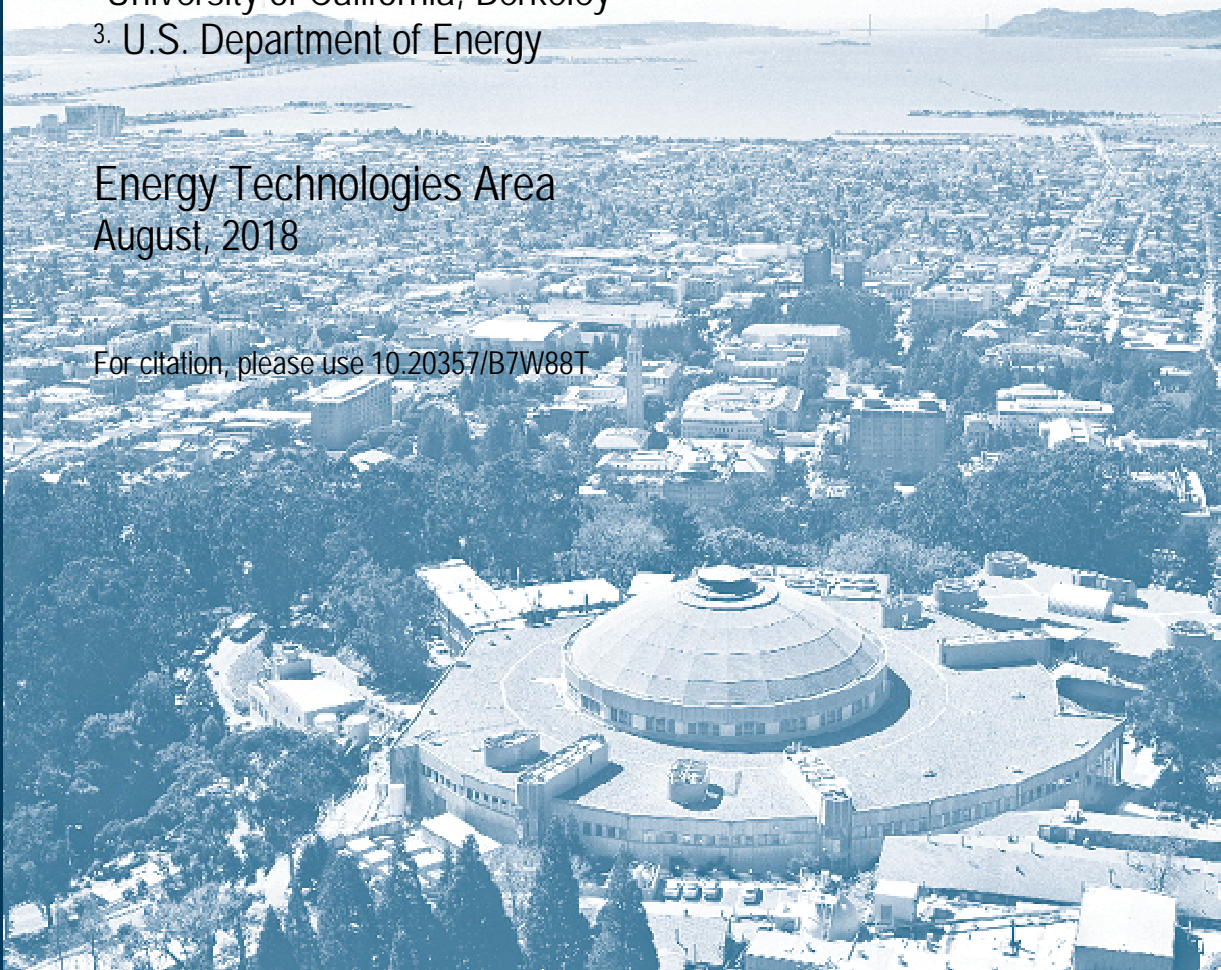
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ABSTRACT

This paper presents new results on the link between energy factors and commercial mortgage default. First, we summarize results from an empirical analysis of the impact of source energy use intensity (EUI) and electricity prices on mortgage default. We used a unique data set that merges building-level energy use data from city benchmarking ordinances and financial data for commercial mortgages on the same buildings. We found that building source EUI and electricity price are statistically and economically associated with commercial mortgage defaults.

Next, we present five case studies on the impact of energy use and price variations on default risk: three office buildings, a hotel, and a multi-family residential building. We use the empirical model coefficients to compute the default risk impacts due to variations in source EUI and electricity price over the course of the mortgage term. We found that variations in source EUI could raise or lower the default rates in these properties by between 5% and 40%, depending on the property type and geography. Electricity pricing has an even greater effect – roughly 60% change in default rate in the Denver area and nearly 90% in northern California.

Finally, we propose an energy risk score that lenders can use to assess energy risk and inform mortgage terms. The score is being developed and piloted in collaboration with three mortgage lenders. We conclude with implications of this score as a market signal and mechanism for incentivizing energy efficiency investments through the commercial mortgage channel.

Introduction

Commercial mortgages currently do not fully account for energy factors in underwriting and valuation, particularly with regard to the impact of energy costs on an owner's net operating income (NOI). As a consequence, energy efficiency is not properly valued and energy risks are not properly assessed and mitigated (Jaffee et al. 2013, Mathew et al. 2016a). A scoping study sponsored by the U.S. Department of Energy (Mathew et al. 2016b) identified several opportunities to properly incorporate energy factors in commercial mortgage valuation, including the following: 1) show lenders that energy costs actually “move the needle,” i.e., materially impact underwriting; 2) develop simple and replicable underwriting requirements and methods for energy factors; 3) incorporate energy performance information in appraisals and property condition assessments.

In this paper, we first present new results on the link between energy factors and commercial mortgage default using a unique data set that merges building-level energy use data

from city benchmarking ordinances with financial data for commercial mortgages on the same buildings. Next, we present five case studies on the impact of energy use and price variations on default risk: three office buildings, a hotel, and a multi-family residential building. Finally, we propose an energy risk score and a process to integrate it into the underwriting process.

Impacts of Energy on Mortgage Default – an Empirical Analysis

There have been a number of studies looking at the relationship between energy efficiency or ‘green’ features and the financial value of buildings. A recent literature review identified over 40 peer-reviewed publications in this area (see, for example, Dermisi 2009, Eicholtz et al. 2013, Fuerst and McAllister 2011, McGrath 2013, Pivo 2013, Reichardt 2014, Robinson and McAllister 2015). Most of these studies examine the relationship between rent and price premiums and Energy Star and LEED certifications. In general, these studies do not consider the operating (particularly energy) costs of the buildings. The purpose of the analysis we conducted was to evaluate the impact of actual energy efficiency and energy cost on the default performance of securitized commercial mortgages. The complete analysis is documented in a technical report (Wallace et. al 2018) and we present key elements of the approach and findings below.

The analysis used a dataset that merged primary loan-level mortgage data from Trepp, LLC and building energy performance data from the benchmarking ordinances of Boston, Chicago, Minneapolis, New York City, Philadelphia, and Washington, DC. Trepp LLC’s loan-level origination and performance data includes information on the structure of the mortgage contract, property and leasehold characteristics, and monthly performance records. Loan default was defined to be when the loan is at least 60 days delinquent, in bankruptcy, real estate owned (REO),¹ or in foreclosure. The building data from the benchmarking ordinances include the site energy use intensity (EUI), source EUI, and Energy Star score based on actual energy use. We used both a linear probability model and a logistic regression model to relate default rate to energy variables, controlling for the underwriting characteristics of the loan at origination, such as interest rate, loan-to-value (LTV) ratio, time to maturity, etc. The energy variables we examined include source EUI, site EUI, Energy Star score, and “electricity price gap,” computed as the cumulative difference between the electricity price at mortgage origination and the electricity prices over the mortgage holding period..

We found that both source EUI and electricity price gap have a positive and statistically significant association with the default of commercial mortgages (Table 1), suggesting that properties that are exposed to more energy cost risk -- all else being equal -- are more likely to default. Site EUI and Energy Star score also show the anticipated associations with default – positive and negative, respectively – but at a lower level of statistical significance².

¹ REO, “real estate owned,” is the term for a loan’s status when the lender exercises its right to take back the loan due to foreclosure and holds the underlying real estate value on its balance sheet in lieu of the loan balance.

² For detailed results, see Wallace et. al (2018).

Table 1. Estimates for loan-level default using log source EUI: linear probability specification (foreclosure or REO = 1)

Parameter	Coefficient Estimate	Standard Error	t test	Prob > t
Intercept	-0.40444	0.18466	-2.19	0.029
Log Source EUI	0.07335	0.03129	2.34	0.0195
Origination Loan-to-Value Ratio	0.00258	0.00096055	2.69	0.0074
Coupon Spread to 10 Yr. Treasury	0.02188	0.01565	1.4	0.1628
Electricity Price Gap	0.00003483	0.00001188	2.93	0.0035
Time to Maturity on Balloon	-0.00189	0.00060375	-3.13	0.0018
Origination Year Fixed Effects	Yes			
R ²	0.1052			
N	473			

What Does this Mean for Specific Buildings? A Study of Five Buildings

The applicability of these results to a specific loan for a specific building is dependent on the context and characteristics of the subject building. From an underwriting perspective, the ensuing issue is to understand the default risk implications for individual loans. We collaborated with three lender organizations – Colorado Lending Source, Northmarq, and Silicon Valley Bank – to analyze specific buildings in their respective loan portfolios. We analyzed five buildings (Figure 1). For each building, we calculated default risk variation due to variations in energy use (source EUI) and electricity price. The results of this analysis are documented in a technical report (Mathew et al. 2017) and summarized below.

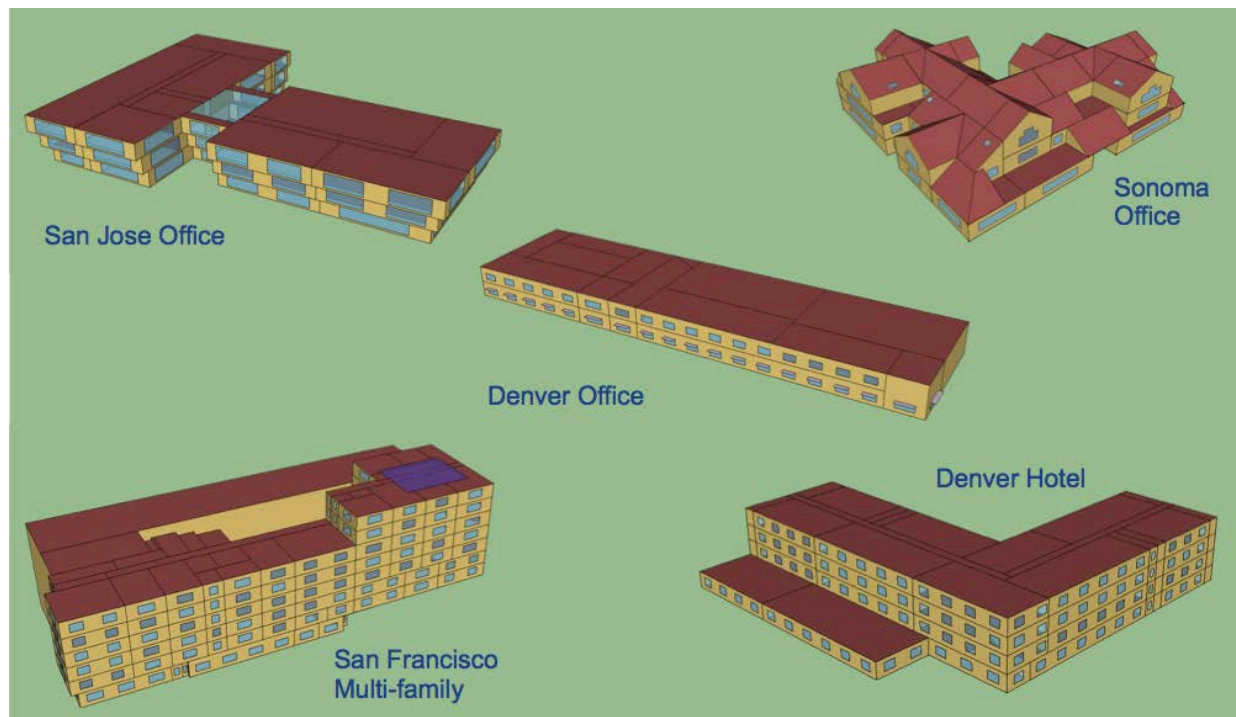


Figure 1. Schematic drawings of five buildings used for the analysis.

Impact of variations in energy use

We used the following simulation-based approach to compute default risk due to source EUI variation (see Figure 2):

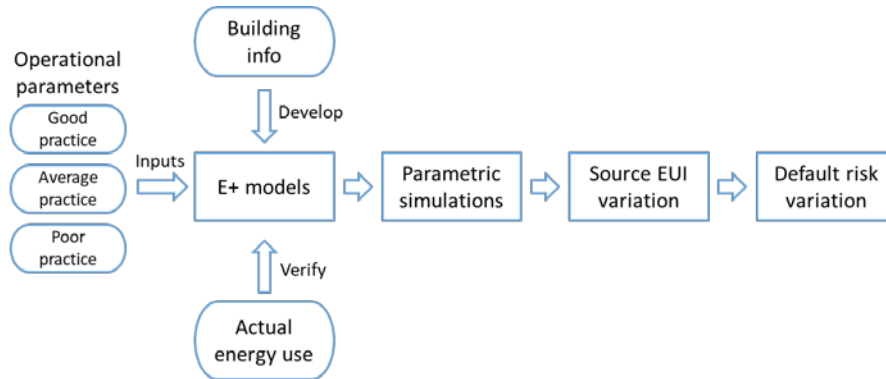


Figure 2. Simulation-based approach to compute default risk variations

- Compile available physical and operational characteristics for each building. We used information ordinarily collected and generated as part of the mortgage process (e.g., appraisals, property condition assessments) or easily available via public sources (e.g., Google Earth).
- Develop an EnergyPlus building energy simulation model based on the available information. The model accounted for: building geometry, HVAC type, window size and location, and assumptions about building envelope, HVAC, and lighting efficiency based on year of construction. Most other parameters (e.g., occupancy schedules, etc.) were defaulted to “typical” values drawn from the DOE reference building models³.
- Compare the modeled energy use to actual energy consumption of the building, if available. If actual energy data were not available, we compared the simulated values with measured data from similar buildings in the Building Performance Database (BPD)⁴.
- Define a list of operational parameters that have the largest impact on source EUI. The list of parameters were based on prior studies and edited based on the features of each building. For example, the hotel building included a parameter to account for different levels of vacancy. It should be noted that the list of operations parameters modeled was not comprehensive and there are any number of additional operational parameters that affect energy use but were not part of this analysis, due to modeling limitations or scope.
- For each operational parameter, define three levels of practice: good, average and poor. Good practice represents design intent or optimal performance of the building. For average and poor practice, the analysis assumes the building has the capability to run at the good practice level, but runs less efficiently due to poorer facility management or occupant behavior. For example, Table 2 shows the operational parameters and levels of practice used for the Denver office building. The levels of practice were developed based on expert input from industry practitioners and building researchers.
- Run the parametric simulations to obtain ranges of source EUI due to different levels of practice. First, we simulated good and poor levels of practice for each parameter, keeping

³ <https://energy.gov/eere/buildings/commercial-reference-buildings>

⁴ <https://bpd.lbl.gov/>

all other parameters at the average level of practice. This provided the range due to each variable. Next we modeled scenarios that represented various combinations of practice levels, including extreme cases where all were good or poor. This provided an overall range of source EUI.

- If actual energy use was available, we applied the relative (%) source EUI variations from the simulation results to actual energy use. If not available, we just used the simulated source EUI values for each scenario.
- Compute default risk due to source EUI variations for each scenario. We used the variable coefficients from linear probability specification of the default risk model to calculate the change in default risk due to the change in source EUI.

Table 2. Range of practice for various operations parameters used for computing source EUI variations for Denver office building

Factor	Good practice	Average practice	Poor practice
Lighting controls	Daylight-dimming + occ sensor	Occ sensor only	Timer only
Plug load controls	Turn off when occupants leave	Sleep mode by itself	No energy saving measures
Plug load intensity	0.4 W/sf	0.75 W/sf	2.0W/sf
Occupant density	400 sf/person	200 sf/person	130 sf/person
Occupant schedule	8-hour workday	12-hour workday	16-hour workday
HVAC schedule	Optimal start	2hr +/- occupant schedule	n/a
Thermostat settings	68°F heat, 78°F cool Setback: 60°F - 85°F	70°F heat, 76°F cool Setback: 68°F - 80°F	72°F heat, 74°F cool No setback
Supply air temp reset	Reset based on warmest zones	Reset as stepwise function of outdoor air temperature	Constant supply air temperature
VAV box min flow settings	15% of design flow rate	30% of design flow rate	50% of design flow rate
Economizer controls	Enthalpy	Dry bulb	None/broken

Figures 3-5 show the relative changes in source EUI and default risk for scenarios that represent various combinations of practice levels for the three office buildings. The parameters were grouped into two categories:

- Facilities management (FM) parameters are those largely controlled by the building facilities management staff. These include parameters such as HVAC schedule, thermostat settings, supply air temperature reset, VAV minimum flow settings, economizer controls, chilled and hot water temperature reset, and lighting controls.
- Occupancy practices (OP) are largely a function of occupant behavior and business function, with little or no facilities influence. These include parameters such as occupant density, occupant schedule, plug load density, and plug load controls.

The default rate change is shown as basis points (bp). As a point of reference, the average default risk in the TREPP dataset is 800 bp (8%). Thus, a 200 basis point change is a 25% change from the TREPP average default rate.

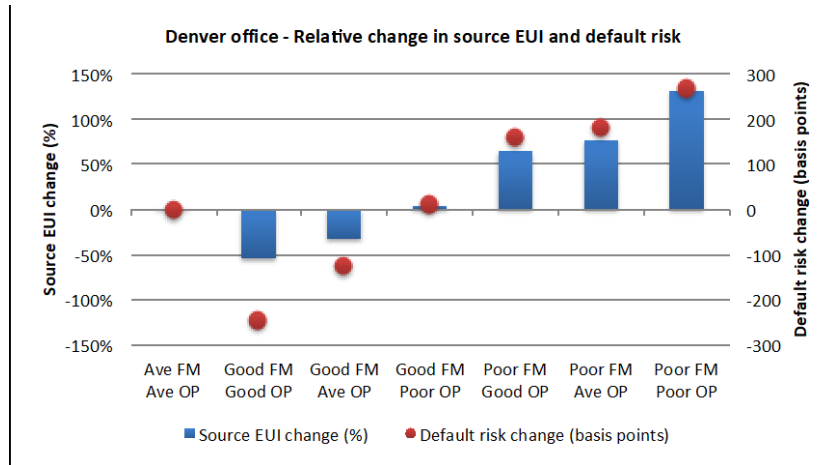


Figure 3. Relative changes in source EUI and default risk due to various levels of facilities management (FM) and occupancy practice (OP) for Denver office building.

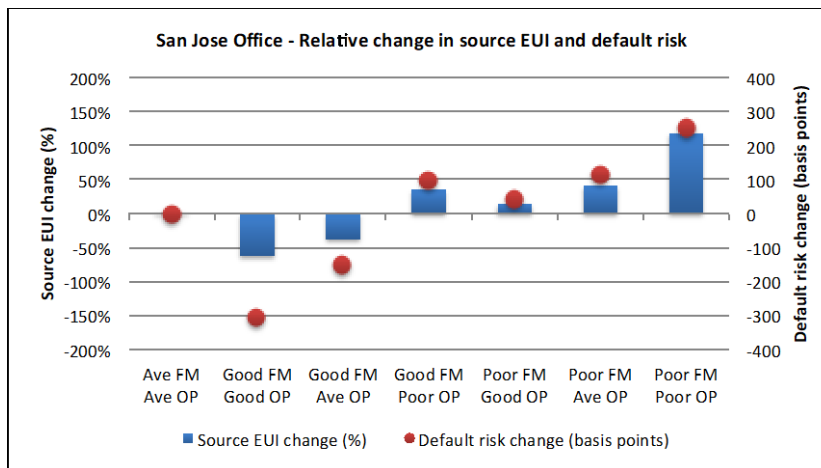


Figure 4. Relative changes in source EUI and default risk due to various levels of facilities management (FM) and occupancy practice (OP) for San Jose office building.

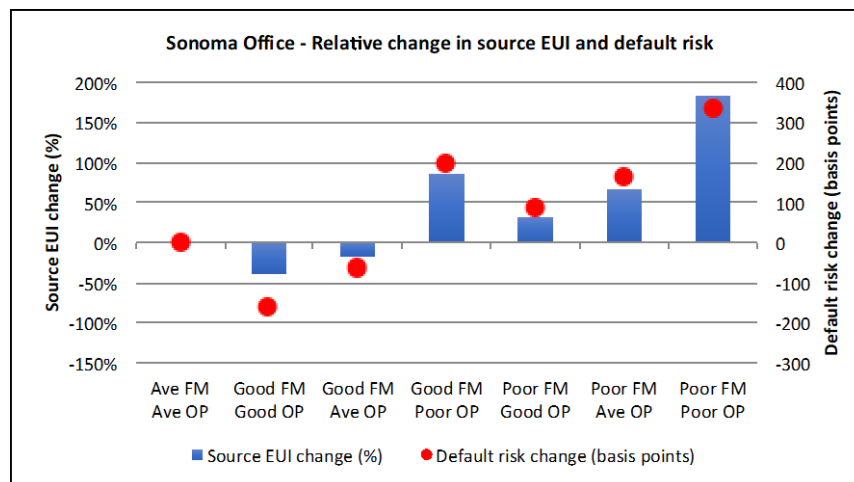


Figure 5. Relative changes in source EUI and default risk due to various levels of facilities management (FM) and occupancy practice (OP) for Sonoma office building.

Figure 6 shows the relative changes in source EUI and default risk for scenarios that represent various combinations of practice levels for the Denver hotel. The parameters were grouped into three categories:

- Guest room vacancy level (Vac), i.e., the percentage of guest rooms that are vacant.
- Guest room vacancy controls (GC) refer to how guest room HVAC and lighting are controlled in vacant guest rooms.
- Common area (CA) parameters include common area (e.g., hallways and lounges) thermostat settings, economizer controls, lighting controls and domestic hot water settings.

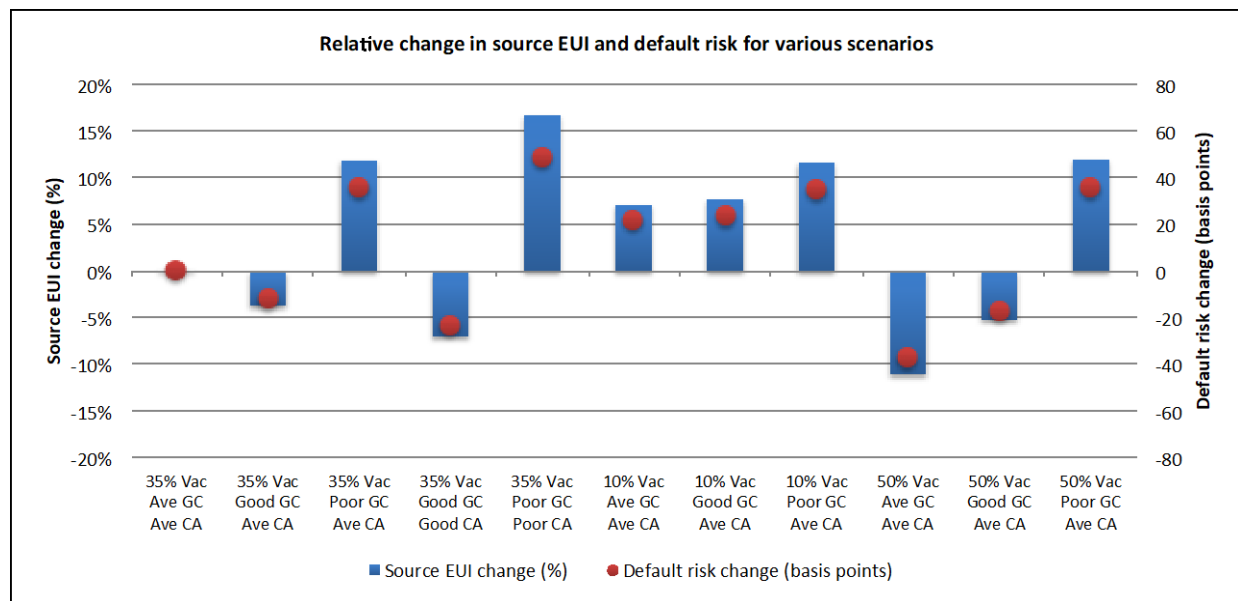


Figure 6. Relative changes in source EUI and default risk due to various levels of vacancy (Vac), guest room controls (GC), and common area (CA) practices for Denver hotel.

Figure 7 shows the relative changes in source EUI and default risk for scenarios that represent various combinations of practice levels for the San Francisco multi-family building. The parameters were grouped into three categories:

- Residential daytime occupancy level (Occ) – i.e., percentage of units that are occupied during the day.
- Residential operations practice (RO) – i.e., how HVAC and lighting is controlled during unoccupied periods.
- Plug load intensity (PL) in residential units. In this context, "good" refers to low intensity and "poor" refers to high intensity.
- Facilities management (FM) parameters include common area lighting controls, thermostat settings, and domestic hot water settings.

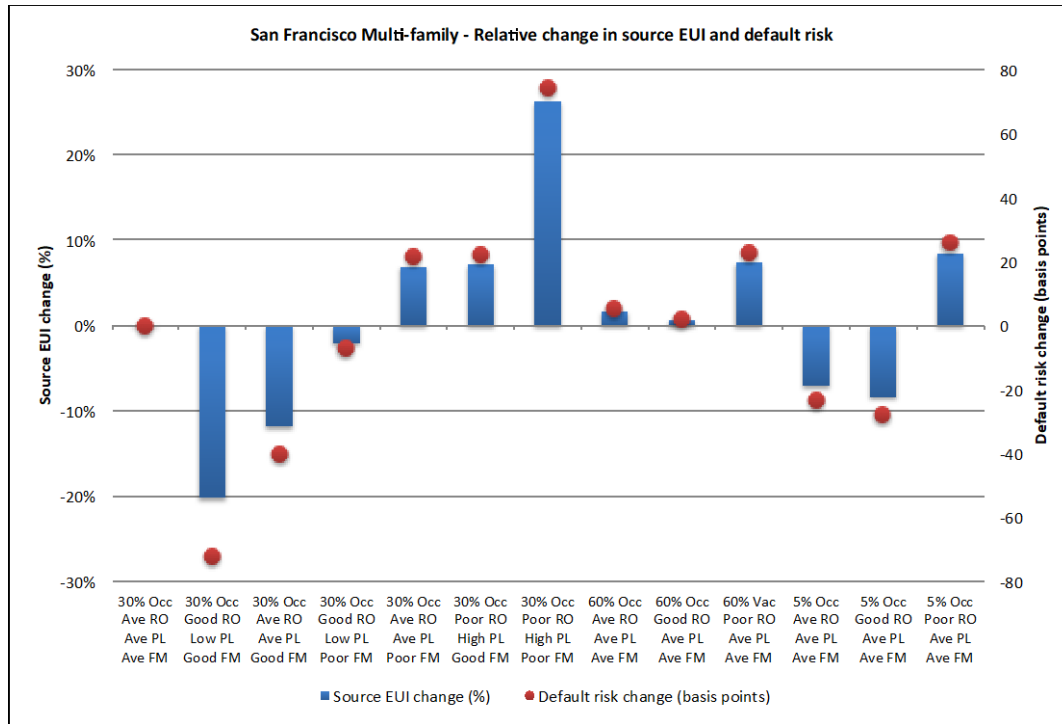


Figure 7. Relative changes in source EUI and default risk due to various levels of daytime occupancy (DO), resident operations practice (RO), resident plug load intensity (PL) and facilities management (FM) for San Francisco multi-family building.

Impact of electricity price

We computed the default risk due to electricity price using wholesale electricity prices for the two regions where the case study buildings were located: Denver, represented by the Palo Verde electricity market region, and northern California, represented by the California Independent System Operator's (CAISO's) NP-15 electricity price region. We used the following approach:

- Compile electricity price data for five-year period. Our intent was to obtain five years of data starting at the mortgage origination date. However, due to limitations in data availability, we were not able to do this and instead used data that were as close as possible to the mortgage origination.
- Simulate 10,000 electricity price paths based on forward market prices.
- Calculate electricity price gap for each simulated path.
- Generate a probability distribution of the electricity price gap at the end of year five.
- Calculate the default risk due to the variation in electricity price gap. We used the variable coefficients from the default risk linear probability model to calculate the change in default risk due to the change in electricity price gap.

An important caveat is that the wholesale prices are only a proxy for the actual prices for this particular building, which were not available for this analysis. The actual energy price risk for each of these buildings is dependent on its utility rate structure and specifically the extent to which those rates are fixed. However, it is reasonable to assume that retail rate variations will correlate with wholesale ones, as captured in this energy price gap measure, over the course of the facility's mortgage term, albeit with some time lag.

Figure 8 shows the distribution of energy price gaps and corresponding change in default rate for Palo Verde. The mean change in default is 330 bp with a standard deviation of 171 bp. Figure 9 shows the same for CAISO NP-15. The mean change in default is 328 bp with a standard deviation of 377 bp – comparable to the impacts of source EUI variations.

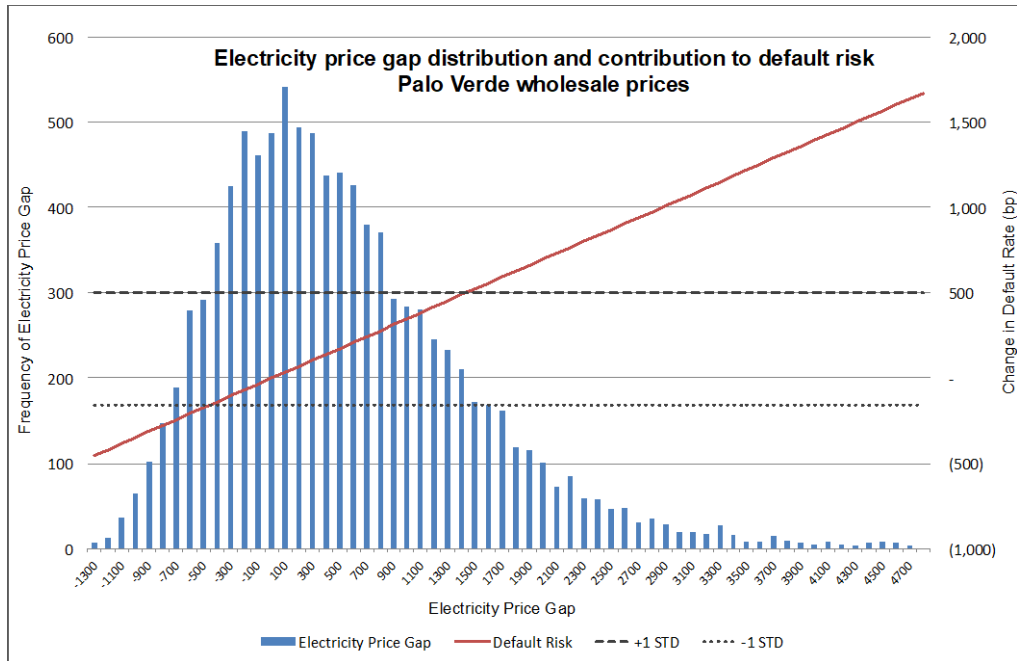


Figure 8. Electricity price gap distribution and contribution to default risk, based on Palo Verde wholesale electricity prices 2010-2015

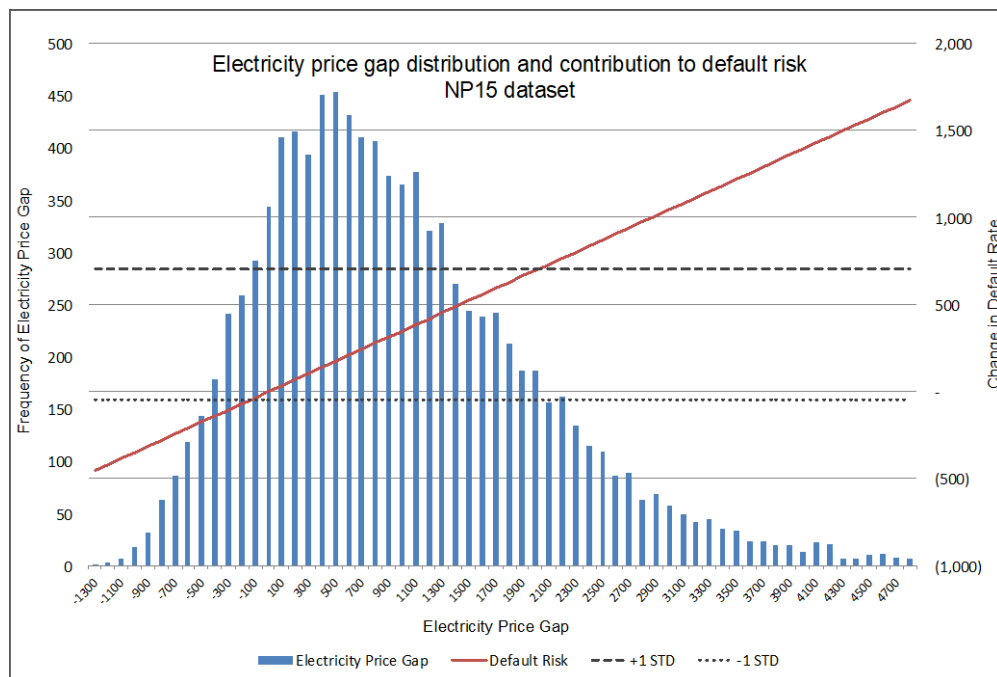


Figure 9. Electricity price gap distribution and contribution to default risk, based on NP-15 wholesale electricity prices 2010-2015

Summary and limitations

Table 3 shows the variation in source EUI due to operations and the corresponding default risk for each building. The table also shows the default rate variation relative to the TREPP average default rate of 800bp.

Table 3. Variation in source EUI and default risk for five case studies.

Building	Source EUI variation (%)	Default rate variation (bp)	Default rate variation relative to 8% avg. (TREPP)
Denver Office	-54% to +132%	-248 to +268	-31% to +34%
Sonoma Office	-40% to +183%	-161 to +331	-20% to +41%
San Jose Office	-62% to +119%	-308 to +249	-39% to +31%
Denver Hotel	-11% to +17%	-37 to +49	-5% to +6%
San Francisco Multi-family	-20% to +26%	-72 to +74	-9% to +9%

To summarize, we found that variations in energy use that are reasonably common could raise or lower the default rates in these properties by between roughly 5% and 40%, depending on the property type and geography. This is a fairly significant potential impact, especially given our prior finding that the industry generally does not take energy usage into consideration in assessing loans [Mathew et al., 2016b]. Similarly, Table 4 shows the relative range in default risk corresponding to one standard deviation variation in electricity price gap for the Denver area and northern California. The relative impacts of prices are even more significant.

Table 4. Variation in default risk due to electricity price gap for the Denver area and northern California.

Wholesale price region	Default rate variation (bp)	Default rate variation relative to TREPP avg (%)
Denver area	+159 to +501	+20% to +63%
Northern California	-49 to +705	-6% to +88%

It is important to note the limitations of this study:

- The source EUI variations are based on a limited number of parameters. In that sense, they are somewhat conservative and the actual range for these buildings could be higher. This is especially true for the Denver hotel.
- The default rate calculations assume that the default rate coefficients from the linear probability model are generally applicable to each of these buildings individually.
- The electricity price gap variations are based on wholesale electricity price, and not the specific retail rate for these buildings.
- The study does not distinguish between net and gross leasing structures.

Given the above, these results should be seen as indicative of the default risks, rather than precise estimates of default rate for a given building.

Looking Ahead: an Energy Risk Score for Mortgage Underwriting

We presented and discussed these findings with each of the three lender organizations that provided the data for these case studies. All of them indicated that these findings are meaningful and that the range of default risk variations are material. As one lender stated, “These results showing the impact of energy on default risk are clearly meaningful. I don’t currently consider energy efficiency when making a loan and seeing this makes me think I would want to ask about it.”

We also discussed potential approaches to effectively incorporating energy costs and risks into the underwriting process. There are well-established methods to analyze energy use, costs, and risks. These include audits, benchmarking, utility bill analysis, etc. ASHRAE has guidelines for three levels of energy audits [ASHRAE 2011]. ASTM 2797-15 establishes a standard specifically for assessing energy performance in the context of a real estate transaction, and includes analysis of variation [ASTM 2015]. However, a key market limitation is that most lenders do not have the interest or expertise to use such detailed information. Furthermore, there continue to be pressures to limit the cost and time for engineering analyses. The lenders suggested that it would be more viable to have a simple risk ratio or score that they could use during underwriting. For example, seismic and other natural hazard risks are currently captured in a simple numeric score with thresholds. If the building exceeds the threshold risk, the lender can either reject the loan or require mitigating measures.

Based on these discussions with lenders and other stakeholders, we recommend the following in the near term:

- Lenders should request an estimate of energy cost variations as part of the loan application. This may be based on historical utility bill data or more in-depth analysis if that is available. At a minimum, this will provide lenders a range of variation that they can factor into the NOI analysis. More broadly from a market transformation standpoint, it will signal to owners that energy costs matter to the lender.
- Develop a simple energy risk score that can be used for underwriting, analogous to the seismic risk score. Notably, the lenders indicated that they would be willing to pilot such a score on new loans.

As part of this ongoing U.S.DOE-sponsored project, the authors are currently working on developing potential approaches for an energy risk score. In addition to being simple to use, the other key consideration is that it should be closely and directly tied to underwriting metrics such as NOI. One potential metric for the energy risk score is simply the ratio of annual energy cost to NOI. This accounts for the energy cost *relative* to NOI. If two buildings have the same energy cost but different NOIs, it will properly evaluate the building with lower NOI as having higher energy-related risk and vice versa. The underwriting process may incorporate additional evaluation of energy risk in a stage-gated manner. For example, if the energy cost to NOI ratio is above a certain threshold, the lender could require an Energy Star score and/or a DOE Asset Score⁵ to evaluate whether the energy risks are due to operational factors, asset characteristics, or energy prices. The score could be calculated and documented as part of the appraisal or the property condition assessment (PCA). We expect to pilot our approach with several lenders toward eventually developing a standard approach to routinely incorporate energy risk analysis into mortgage underwriting.

⁵ <https://energy.gov/eere/buildings/building-energy-asset-score>

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