Connecting Environmental Performance Analysis to Cash Flow Modeling for Financial Valuation of Buildings in Early Design

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Abstract

We propose a new design workflow that links environmental performance analysis and financial cash flow modeling. The purpose of this work is to associate sustainable design measures with their potential economic premiums. Our approach assumes that the value of a design intervention is correlated with its financial return: incremental increases in design performance leads to proportional increases in real estate rent value.

We tested the proposed design and financial workflow in six pre-concept urban design projects in Boston, Lisbon and Kuwait City. We optimized daylight availability and walkability in each project. Then, we applied a premium to the rent price of each space based on the increased design performance. The applied value-add is based on previous empirical research of sustainability premiums in rent prices. Our results show that increasing the rent prices based on performance can provide up to 5% improvement in the simple yield for a project, producing an incremental cash flow in operation of the property. The results illustrate that, in addition to increasing the design quality, improved performance can add economic value to a project.

Introduction

Buildings account for a large portion of our societal resource consumption and produce a similarly notable percentage of the greenhouse gas (GHG) emissions. According to the Intergovernmental Panel on Climate Change, buildings account for 32% of total GHG emissions worldwide (Lucon et al., 2014). At the same time, the built environment is expanding as cities grow with increased urbanization (United Nations Department of Economic and Social Affairs, 2014). As the building stock grows, designing with sustainability in mind becomes ever more critical – firstly, to mitigate the resource strain and GHG emissions; and secondly, to ensure the comfort, health, and wellbeing of the occupants within.

The creators of buildings – design and engineering teams, and the developers and investors – all aim to make them more sustainable, in terms of resource efficiency, economic performance, and occupant comfort and wellbeing. While the aim may be the same, often the design teams and the financial stakeholders take vastly different approaches to achieve the same end. With this work, we aim to bridge the divide between the groups by connecting the methods used in the design and real estate sectors.

Assessing Environmental Design

Design measures addressing energy, resource efficiency, health, comfort, and wellbeing issues can all be broadly categorized as environmental design. These factors are increasingly relevant in the creation of buildings, as they impact the sustainability, as well as the social and economic desirability of a project.

A wealth of design analysis workflows exists in architecture and urban planning to quantitatively assess environmental design measures, such as daylight availability and walkability.[1] As these tools become more accessible, they are adopted more widely and used earlier within the design process. While early design performance analysis tools are increasingly sophisticated, they do not conventionally consider the economic cost or savings associated with the design performance strategy in question. One reason for this may be that these tools are employed far before costing decisions are being made. Ironically, it is precisely during the early stages of a project that the measures can add the greatest value with minimal additional cost. The further along a project is in development, the harder to make changes, as illustrated by the MacLeamy Curve (American Institute of Architects California Council, 2007).

Costing and economic value are not driving early design decisions. However, they could be. While designers are developing the overall concept, investors and developers are concurrently evaluating the project's financial outlook. This is usually done via a real estate pro forma, an analysis of a project's projected financial return over time. A pro forma includes basic project parameters, but it does not usually consider the performance of specific design measures. If environmental design is considered at all, it is most often based on green building certifications. Therefore, any value that *specific* environmental design interventions may have is not being captured by the real estate financial assessment.

On a given project, two types of analysis – design performance and real estate financial valuation – are being conducted in parallel. Yet, there is little overlap of the two in the current practices. We believe that there exists an opportunity to merge the analysis done by designers and investors. Doing so will bring an added insight into the viability and performance of environmental design interventions from both a design and financial perspective.

Financial Value of Environmental Design

Real estate property values are often estimated using a statistical hedonic pricing model (Rosen, 1974). The hedonic pricing model is a multivariate regression that determines the relative impact of various factors on the price of a good. These factors include property type, building age, building class, number of floors, renovations, amenities, transportation accessibility, and investor type. Increasingly a building's sustainability, measured via a green building certification, is included in the list of factors.

In real estate, green building certifications, such as the US-based Leadership for Energy and Environmental Design (LEED) and UK-based BRE Environmental Assessment Method (BREEAM), are the most commonly used indicator of sustainability. Certifications are a third-party assessment of environmental performance over a standard baseline building. Using the hedonic model, one can identify the impact of sustainability certifications on the price of rent and sale prices of a property. These labels are easily incorporated into the hedonic pricing model as all certified buildings are assessed based on the same set of standards and can be easily distinguished from non-certified buildings.

Empirical literature consistently finds that certified sustainable buildings command a financial premium over conventional buildings in both rental and sales transactions. This trend is true in the residential and commercial markets, though notably more pronounced in the latter (Deng & Wu, 2014).

There have been at least seven large scale empirical studies on commercial properties that have identified a premium of 13% to 30% on the sales transaction prices; and for rental properties, a cash flow increase of 6.5% to 21.5% (Chegut, Eichholtz, & Kok, 2014; Eichholtz, Kok, & Quigley, 2010, 2013; Fuerst & McAllister, 2011; Kok & Jennen, 2012; Miller, Spivey, & Florance, 2008).

Similar results have been found for residential properties, in both the private and affordable housing sectors. Properties with elements of sustainability certification have shown to have a sales transaction price premium of 2% to 15% (Brounen & Kok, 2011; Brounen, Kok, & Quigley, 2012; Cerin, Hassel, & Semenova, 2014; Chegut, Eichholtz, & Rodrigues, 2015; Copiello, 2015; Dastrup, Graff Zivin, Costa, & Kahn, 2012; Deng, Li, & Quigley, 2012; Feige, Mcallister, & Wallbaum, 2013; Hyland, Lyons, & Lyons, 2013; Kahn & Kok, 2014; Schaffrin & Reibling, 2015; Yoshida & Sugiura, 2014; Zheng, Wu, Kahn, & Deng, 2012).

Beyond Green Certifications

Sustainability assessment schemes are purposefully holistic, encompassing all aspects of environmental performance from energy efficiency to transportation access and ecosystem services. As they are comprehensive, they are also generalized, indiscriminate, and can be idiosyncratic to political and cultural concerns. To better understand the contributions of individual design components, there has been efforts to "look under the hood" and assess the impact of specific attributes and their contribution to the overall sustainability value of a building.

Walkability and accessibility to amenities and services have been the focus of most of the studies published to date in this area. Kok and Jennens evaluated the impact of accessibility of public transportation and amenities on office rental prices in the Netherlands. Using the metric Walk Score (Walk Score, 2016), the authors found that tenants pay higher rent prices for office spaces located in areas with a range of amenities in comparison to properties located in "mono-functional" areas (2012). Similarly, Fuerst and Wetering determined that in the UK, tenants pay the most for rental properties with the highest Walk Score rating. Though, they note that this is not necessarily the case for properties with the second highest walkability rating (2016). Pivo and Fisher similarly found that, in the United States, office and retail properties with a Walk Score of 80 command a 54% premium in market value and 42% premium in net operating income over properties with a Walk Score of 20 (2011).

Feige, Mcallister, and Wallbaum have come the closest to connecting the performance of multiple nvironmental design elements to real estate value. They assessed the effects of 36 different environmental design indicators, including water efficiency, and health and comfort, on the rent prices of 2,500 residential buildings in Switzerland (2013). To assess all of the factors, the authors rated each sustainability feature from -1 (below common standards and norms) to +1 (exceeding common standards and norms) in 0.1 increments. The study found that water and energy efficiency have the greatest positive effect on rent prices, with a 1.1% price increase per 0.1 difference in their sustainability score. Factors related to health and comfort, and safety and security increased prices by 0.9% per 0.1 change in sustainability score. Surprisingly, the authors found that a higher accessibility and mobility score tended to decrease the rent prices. The authors reason that this is likely because in Switzerland the most expensive properties are in the historical city centers. The older buildings and narrow streets that constitute these areas are generally less amenable to bicycle parking, resulting in a negative relationship between the mobility and price.

Feig, Mcallister and Wallbaum normalize the performance of the 36 sustainability factors on a scale of -1 to +1 in order to evaluate all features together. To our knowledge, there have been no other studies that associate specific building performance results other than Walk Score to the value of a property. This study is meant to lay the groundwork on which to evaluate environmental design factors and their economic outcomes based on specific performance results. We propose utilizing existing environmental design analysis tools to this end. We believe that connecting design analysis and financial analysis methods can provide more nuanced – and potentially more accurate – valuation of buildings and their sustainable properties.

Methodology

We propose a framework for linking two environmental performance analyses, daylight availability and walkability, to the simple yield estimate of a project. Daylight availability is a description of how much daylight (i.e. the visible portion of solar radiation spectrum) is present in a space in given time period. It is commonly measured by the metrics daylight factor, daylight autonomy, and useful daylight illuminance (Reinhart, 2014). Walkability is "the degree to which an area within walking distance of a property encourages walking trips from the property to other destinations" (Pivo & Fisher, 2011). It is dependent upon a multitude of physical and social factors, such as the quantity and proximity of amenities, the street connectivity, topography, traffic volume, sidewalk width, and safety.

The purpose of this work is to compare how rent income may change if the quality of daylighting and walkability are taken into account in the buildings' financial valuation. The offered method consists of three parts: first, the environmental performance analysis of a given design; second, the baseline financial simple yield analysis; and third, the performance-based enhanced yield analysis. The workflow is presented in Figure 1 and will be described in the following sections. For both daylight

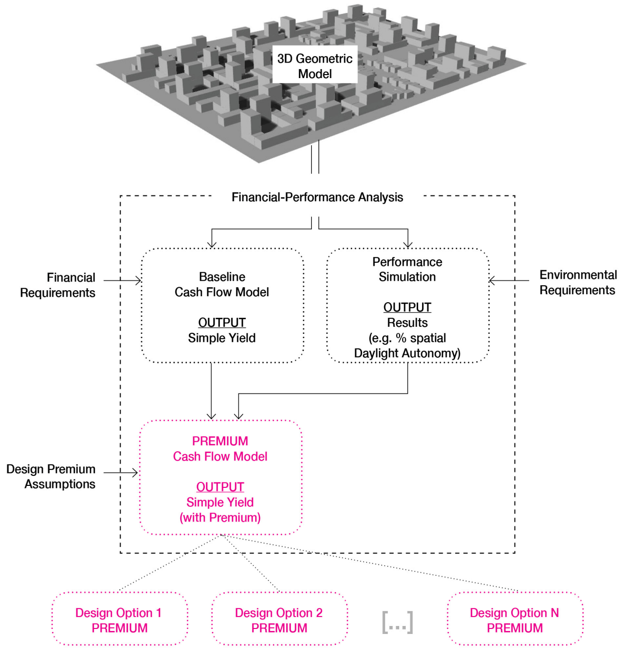


Figure 1: Performance-Finance Analysis Workflow

availability and walkability, we compare the yield of the *baseline* case with the performance premium or *enhanced* case. We additionally looked at what the impact of accounting for both properties *together* would be on the financial yield.

In order for the three-part analysis to be carried out, an integrated urban model of a given neighborhood design is set up to calculate the operational energy, daylight autonomy and walkability. The latter two metrics are the focus of the performance premium analysis.[2]

For this study, we have chosen to work with the tool Urban Modeling Interface or Umi (Reinhart, Dogan, Jakubiec, Rakha, & Sang, 2013). Umi is a plug-in for Rhinoceros 5.0 (Rhino) and Grasshopper (Robert McNeel & Associates, 2016a, 2016b). It enables the user to analyze the performance of various environmental design attributes using an existing Rhino model. Within Umi, a user may combine a

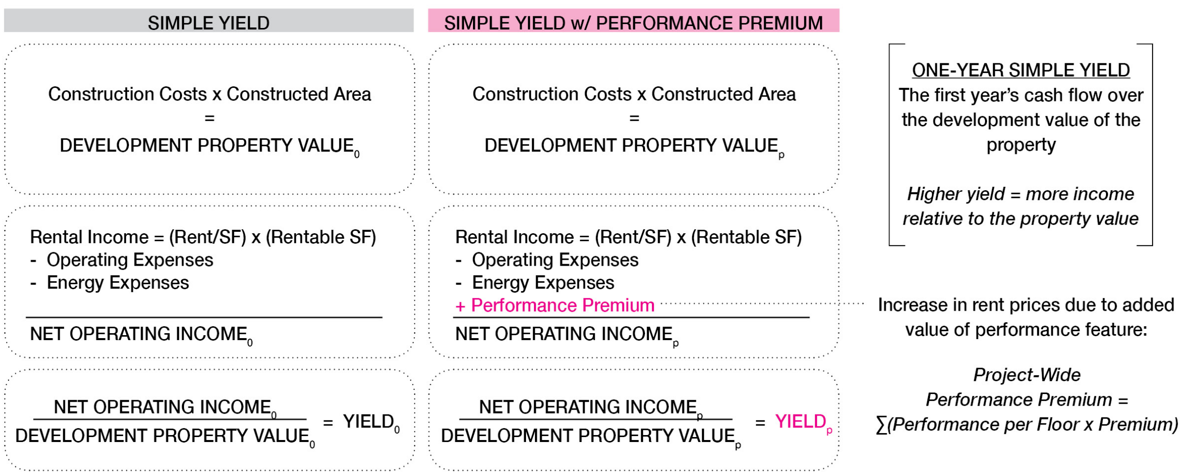


Figure 2: Simple yield calculation with and without performance premium

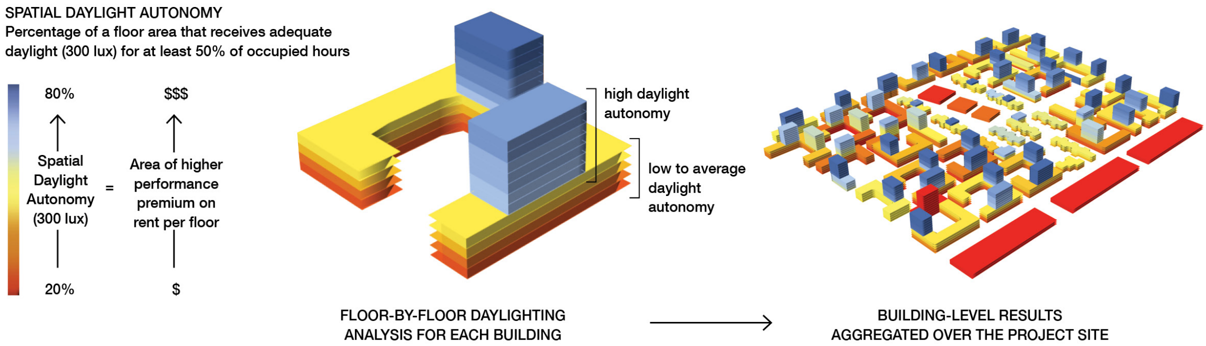


Figure 3: Visualization of daylight availability variations within a neighborhood design proposal for Lisbon, Portugal.

three-dimensional urban building massing model and street grid with custom building templates for a variety of programmatic uses (e.g. residential, office, retail), as well as amenity locations such as schools, shops and restaurants. Based on these inputs, the user can run a series of Umi modules to calculate different environmental performance indicators at the building and neighborhood level.

Environmental Performance Analysis

The performance simulations are carried out and results are stored in the Umi project database.

For operational energy use Umi uses the Shoeboxer algorithm that divides a neighborhood into a series of perimeter-core EnergyPlus models (Dogan & Reinhart, 2017; U.S. Department of Energy, 2015). The module yields hourly heating, lighting, cooling, and equipment loads, along with associated energy uses.

For indoor daylighting levels, Umi combines DAYSIM-based annual illuminance calculations on the façade with a custom light solver in order to efficiently estimate hourly indoor illuminance distributions (Dogan, Reinhart, & Michalatos, 2012). We use the spatial daylight autonomy metric with a target level of 300lux of at least 50% of annual occupied hours ($sDA_{300lux}[50\%]$). This metric describes the percentage of floor area in a space that has an illuminance levels of 300lux or more for at least 50% of the occupied hours, measured annually. In other words, sDA describes the percentage of floor area in a building that is acceptably daylit.

For walkability we employ Walk Score, a commercially developed metric widely used to characterize pedestrian accessibility in cities around the world (Walk Score, 2016). We use Umi's walkability analysis module, which is based on a formerly available public version of the Walk Score (Rakha & Reinhart, 2012; Reinhart et al., 2013). The polynomial distance decay algorithm calculates a score from 0 to 100 based on the shortest path on the street grid between a building and local amenities. Different amenities (such as grocery, restaurants, shopping, banks, and schools) are weighted according to their importance or relevance. In this study, the default amenity weights and allowable distances are based on the default values defined in Umi (Reinhart et al., 2013).

Once a neighborhood model has been set up and run in Umi, the project is ready to be assessed in the performance-financial workflow.

Simple Yield Calculation

Simple yield is an estimate of the financial return on a property investment. This term (Equation 1) is the net income received by an investor in one year over the total invested value or price of the property (Geltner, Miller, Clayton, & Eichholtz, 2013).

$$Simple\ Yield = \frac{Annual\ Net\ Operating\ Income}{Property\ Development\ Value} \qquad (1)$$

Simple yield is a back-of-the-envelope method used to evaluate the financial viability of a project. While it does not consider the time value of money, in an efficient market, the simple yield should approximate the overall yield. We choose this metric because it can be used to compare the performance of competing neighborhood designs, ceteris paribus, as outlined in Figure 2.

We calculate the numerator, *Annual Net Operating Income*, based on the aggregation of each month's rent revenue received minus the operating expenses and monthly energy expenses (Equation 2).

$$\begin{aligned} &Gross\ Revenue\ from\ Rent \\ &-Operating\ Expenses \\ &-Energy\ Expenses \\ &= Annual\ Net\ Operating\ Income \end{aligned} \qquad (2)$$

We assume the rent based on the local market rent prices for various types of properties. Monthly energy costs are based on local energy prices and the operational energy simulation results from the environmental performance analysis. The values used in the case studies are cited in a following section.

The denominator, *Property Development Value*, is based on the total cost of construction for each space type in the project – residential, office, and retail (Equation 3).

$$\sum_{space\ type} \begin{pmatrix} Construction\ Costs\ x \\ Gross\ Built\ Area \end{pmatrix} = Property\ Development\ Value \qquad (3)$$

The construction costs are based on local market costs for each building type. The gross built area is calculated based on the three-dimensional model in Umi. The values used in the case studies are cited in a following section.

Enhanced Financial Yield Analysis

The enhanced financial yield value applies a "performance premium" to the baseline simple yield financial calculation, as outlined in Figure 2. The performance premium is based on a numerically estimated environmental design metric. Any type of analysis result can be used so long as it is disaggregated by individual buildings or spaces, and there is a numerical distribution of possible performance results.

In the case of this study, we consider daylight availability and walkability. Figure 3 shows, as an example, the distribution of daylight availability for a neighborhood design proposal in Lisbon, Portugal. The higher the spatial daylight autonomy, the greater the rent value of the space. For all areas with a sDA_{300lux} more than 50% of the occupied hours, it is assumed that there will be an increase in the rent price based on the premium.

The workflow for performing the performance-finance calculation is illustrated in Figure 1. The simple yield is calculated with a performance premium factor applied to the areas with optimized performance (i.e. sDA_{300lux}[50%] and higher Walk Scores).

Case Study: Six Neighborhood Design Proposals

The proposed framework was applied to six urban design proposals. The neighborhood developments were originally conceived by six student groups in a graduate-level seminar on modeling urban energy flows at the authors' home institution in the 2016 spring term. The class had an enrollment of 26 students from a variety of degree programs, from architecture and building technology to city planning, urbanism and civil engineering.

The semester-long class project was to develop a mixed-use sustainable urban design proposal for predefined sites located in Boston, Lisbon, and Kuwait City. Two proposals were created for a site in each of the three cities. Students learned how to use Umi's suite of performance modules; and each team carried out a complete Umi analysis of operational and embodied energy use, along with daylight, walkability and outdoor thermal comfort simulations. The basic design parameters and performance simulation results for each project are presented in Table 1.

The teams sourced local values for rent prices, construction costs, and energy prices to establish the cost assumptions for the simple yield calculations, as presented in Table 2. [3]

Using the simulation results, the groups carried out the performance-finance analysis for each project. For the Boston and Lisbon projects, both daylight availability and walkability were considered individually, and then together (assuming that there is a compounding increase in value due to both performance measures). For Kuwait City, only daylight availability was considered. Walkability was not included because there is limited opportunity to

Table 1: Project Parameters and Performance Results

	Boston		Lisbon		Kuwait	
	Design 1	Design 2	Design 1	Design 2	Design 1	Design 2
Project Parameters						
Building Area (m2)	422,000	336,000	429,000	485,000	289,000	313,000
Total Construction Costs ($ million)	$973.09	$785.20	$547.84	$600.76	$534.30	$573.41
Performance Results						
Average Operational Energy Use Intensity (kWh/m2)	142	135	84	82	170	141
Site-Wide Daylight Availability (% sDA)	52%	5%	53%	39%	33%	76%
Walk Score (%)	53%	49%	88%	85%	-	-

expand the scope of pedestrian networks in the city, due to the hot climate and cultural constraints.

The groups applied a range of performance premiums, from 5% to 20% to examine the incremental change in yield with the increasing premium. They chose the range of premiums to be in line with the results of previous empirical studies on the price premium of sustainability certifications and Walk Score. For example, for commercial properties the range in certification-related price premiums is from 6% to 15% (Chegut et al., 2014; Eichholtz et al., 2010, 2013; Fuerst & McAllister, 2011; Kok & Jennen, 2012; Miller et al., 2008); 2% to 30% for residential properties (Brounen & Kok, 2011; Brounen et al., 2012; Cerin et al., 2014; Copiello, 2015; Dastrup et al., 2012; Deng et al., 2012; Feige et al., 2013; Hyland et al., 2013; Kahn & Kok, 2014; Schaffrin & Reibling, 2015; Yoshida & Sugiura, 2014; Zheng et al., 2012); and between 40% and 50% for Walk Score (Pivo & Fisher, 2011). While the premiums depend on local market conditions, we deemed the precedent studies to be a good gauge for this speculative examination of the projects in the three cities.

Table 2: Cost Assumptions

	Boston	**Lisbon**	**Kuwait**
Construction Costs ($/m2)			
Residential	$2,500	$1,331	$1,850
Office	$2,100	$1,118	$1,960
Retail	$1,950	$1,038	$1,590
Rent Prices ($/m2/year)			
Residential	$414	$190	$179
Office	$642	$235	$197
Retail	$831	$250	$197
Energy Costs ($/kWh)			
Electricity	$0.1600	$0.1968	$0.0060
Natural Gas	$0.0360	$0.0898	-
Operation Expenses (% of income)			
	20%	20%	20%

Results

The enhanced simple yield and resulting added cash flow was recorded for all cases. Figure 4 presents a summary of the results in charts to illustrate the incremental change in yield and comparison of the two designs for each city.

In Boston, Design 1 has a 4% yield advantage prior to the addition of the premium. With the premium added, Design 1's advantage increases to 7.5% over Design 2. This is unsurprising, as the proposal performs better in terms of both daylight availability and walkability. The increased yield of Design 1 would translate into potentially additional cash flow of $44/m2/year for increased daylight availability, $72/m2/year for walkability, or $115/m2/year if both premiums were combined (with a 20% performance premium). Design 2, while not as advantageous, would still produce an added $5/m2/year for daylight performance, $50/m2/year for walkability, or $55/m2/year for if both premiums were combined.

In Lisbon, Design 2 has a slight yield advantage over Design 1 without the premium at 12.15% versus 11.45%. However, Design 1 performs better than its counterpart in terms of both daylight availability and walkability. As a result, with the added premium, Design 1 becomes a viable competitor and the potential yield for both designs is nearly the same. When both daylight availability and walkability performance premiums are included at 20%, the resulting yield is 15.94% and 16.23% for Designs 1 and 2, respectively. The comparison of the two proposals illustrates how the added premium can change the financial viability of one design versus the other, and reveal potential hidden value within a project. The inclusion of a 20% premium for daylight availability and walkability would result in over $50/m2/year of addition cash flow for either design.

In Kuwait City, the projects have nearly the same simple yield without any premium, roughly 8% for both designs. Design 2 has much stronger daylight availability strategy, and therefore has the potential to yield 9.36% while Design 1's yield could increase to only 8.65%. With the performance benefit, Design 2 could increase cash flow by up to $26/m2/year. With the same 20% premium, Design 1 has the potential to produce $12/m2/year additional cash flow.

Discussion

Accounting for good environmental design – such as increased daylight availability and walkability – in rental prices via a performance premium has the potential to increase cash flow to an owner and operator. This is surely a welcome opportunity for any investor, as the added performance is inherent to the design and does not require any additional costs upfront or in the building's operation.

How does this, on the other hand, impact tenants? For a 100 m^2 residential apartment in Design 1 in Lisbon, for example, the baseline rental cost (i.e. without a performance premium) would be $19,025/year or $1,585/month. With the 20% premium for increased daylighting performance, the price of the same apartment would increase by $2,226/year or $185/month. This is not an insignificant increase in rent – and therefore worth evaluating carefully – but it is also not unreasonable given the range of residential rent prices and the characteristics for which tenants are willing to pay in the real estate market.

Nevertheless, the incremental increase in rent prices is something to be considered carefully, particularly with regards to social equity and affordable housing. What can and should tenants be asked to pay? In some cities, renters are already paying more for better design. In 2016, the Portuguese government passed a "window tax" (Law Decree No. 41 2016) that charges an added tax of up to 20% on homeowners with south-facing solar exposure and views. Inversely, homes that face north, are on bottom floors, or face a cemetery can receive a tax reduction of up to 10% (de Beer, 2016).

The premium values applied in this study are, like the Portuguese tax, ultimately an added burden on the tenants. One may argue that this amplifies social inequality as design performance becomes an amenity that can be bought. However, inversely, if design quality can be quantified both in terms of performance and economic value, it can be better regulated and subsidized to ensure that all individuals are receiving an equal share.

Validation and Next Steps

The method of incorporating the performance premium in the simple yield calculations will be validated moving forward. A sensitivity analysis will be conducted to determine how the simple yield is affected by the various inputs. Additionally, the environmentally performance metrics used in the integrated workflow will be reconsidered, as not all metrics may be appropriate for this analysis. For example, we employed Walk Score as an indicator of walkability, though there are many aspects of pedestrian accessibility that are not captured in the Walk Score methodology. Moving forward, we intend to consider alternative metrics and look at what aspects of environmental design are prioritized by occupants.

Conclusion

Performance design features add to the spatial quality of a building. "Good" spaces are usually those that are also high performing. These traits are often intuitively recognizable by users but not always quantified, particularly in the financial valuation of a project. The aim of this work is to make the features that we often intuit as "good" also acknowledged for their economic value.

The proposed performance-financial analysis framework links the evaluation of environmental design measures and financial modeling to better understand the potential economic benefit of individual environmental design features. The work aims to move beyond the current practice of valuing high performing buildings solely by their sustainability certification label, and be a step towards the full integration of environmental performance analysis and financial projections.

We utilize established performance analysis tools, and assess the impact that performance results would have on the simple yield if they were applied as a premium. The results show that adding a premium based on environmental design performance can impact the expected financial yield of a project. The approach brings to the surface qualities of a project that are not accounted for in the current method of financial analysis. If investors and designers *both* recognize the value-add in early stage design, there is a higher likelihood that such features are integrated into a project, leading to overall more sustainable and high performing buildings. By unveiling the inherent economic value of what we intrinsically know to be good design, environmental design can be bolstered to new heights.

Notes

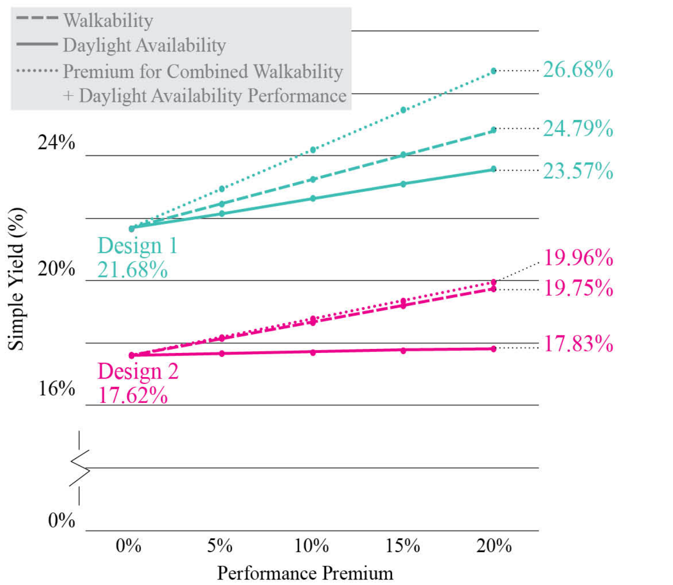
1. A number of performance analysis tools exist to aid in various stages of design development. For early design work, there are plug-ins to the modeling software Rhinoceros and its scripting extension Grasshopper, such as DIVA-for-Rhino (Solemma, 2016), Umi (Reinhart et al., 2013), Ladybug and Honeybee (Roudasri, 2016). A number of other stand-alone programs exist to carry out holistic building performance analysis; these include Green Building Studio, IES Virtual Environment for Architects, Sefaira Architecture, and OpenStudio (Autodesk, 2016; Integrated Environmental Solutions, 2016; National Renewable Energy Laboratory, 2016; Sefaira, 2016).
2. The operational energy simulation is used to calculate the energy use, which determines the energy-related operational expenses. Thus, savings in operational energy are accounted for in the financial calculations but not explicitly considered in the performance premium analysis.
3. The construction costs, rent prices, and energy costs were tailored to each location. These values were determined by the project teams from a variety of sources based on the best available data at the time. The sources used are:

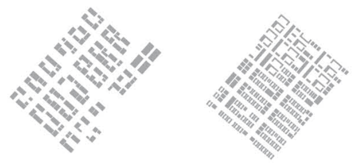
   Construction Costs: Boston – RSMeans Building Construction Cost Data (2016); Lisbon – Camisa, Nuno Daniel Páscoa. "Evolution of the Residential Construction Cost and Price in Portugal – Analysis of the Fundamental Factors." Instituto Superior Técnico, Universidade Técnica de Lisboa, 2015. Print; Kuwait City – Turner & Townsend International Construction Market Survey (2016, Qatar values).

   Rent Prices: Boston – Cushman & Wakefield Office Space Across the World Report (2014); Lincoln Property Company Boston Average Rents (2015)*;* Lisbon – Cushman & Wakefield Office Space Across the World Report (2014): Expatistan.com Cost of Living calculator*;* Kuwait City – Estimates from a local resident.

   Energy Costs: Boston – Electric Power Monthly, U.S. Energy Information Administration (2016)*;* Lisbon – Portugal Energy Services Regulatory Authority, ERSE (2016)*;* Kuwait City – Ministry of Electricity & Water, State of Kuwait (2016).

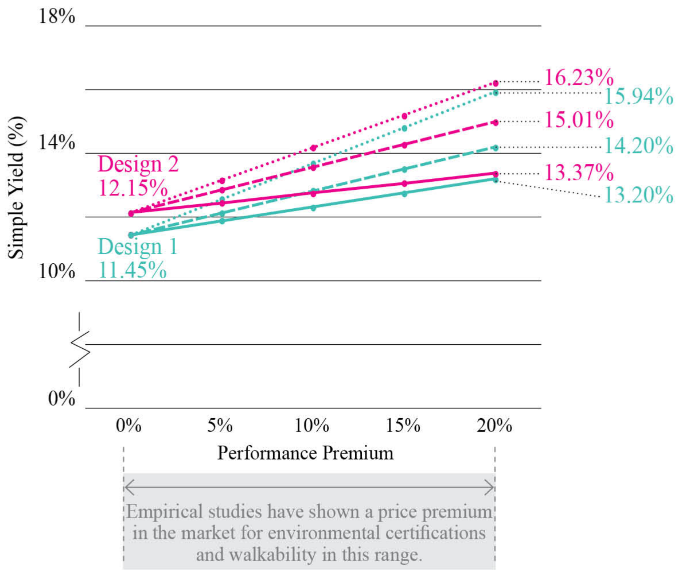
BOSTON

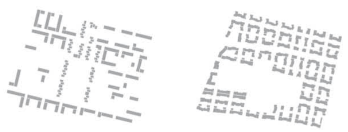




	Design 1	Design 2
Total Built Area (m2)	422,000	336,000
Site-Wide Average Daylight Availability (%sDA)	52%	5%
Site-Wide Average Walkability Score (%)	53%	49%
Potential Incremental Cash Flow @ 20% Premium ($/m2/yr)	daylight: $44 walkability: $72 both: $115	daylight: $5 walkability: $50 both: $55

LISBON

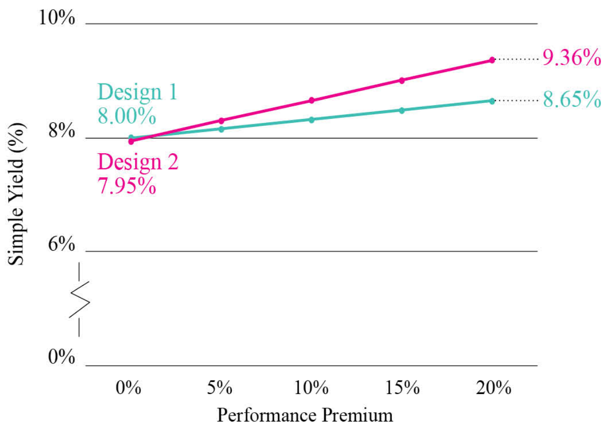


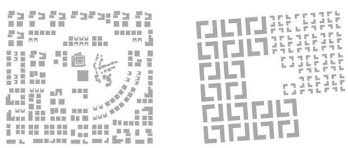


	Design 1	Design 2
Total Built Area (m2)	429,000	485,000
Site-Wide Average Daylight Availability (%sDA)	53%	39%
Site-Wide Average Walkability Score (%)	88%	85%
Potential Incremental Cash Flow @ 20% Premium ($/m2/yr)	daylight: $22 walkability: $35 both: $57	daylight: $15 walkability: $35 both: $51

KUWAIT CITY

*Only daylight availability analysis performed. Walkability not considered.





	Design 1	Design 2
Total Built Area (m2)	289,000	313,000
Site-Wide Average Daylight Availability (%sDA)	33%	76%
Potential Incremental Cash Flow @ 20% Premium ($/m2/yr)	daylight: $12	daylight: $26

Figure 4: Simple yield results with performance premium included for all six design proposals.

Acknowledgement

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