QUANTIFYING THE EFFECT OF GREEN BUILDING CERTIFICATION ON HOUSING PRICES IN METROPOLITAN ATLANTA

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QUANTIFYING THE EFFECT OF GREEN BUILDING CERTIFICATION ON HOUSING PRICES IN METROPOLITAN ATLANTA

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I would like to dedicate this work to my parents who have provided invaluable support and encouragement in the pursuit of this degree and throughout my life.

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List of Abbreviations

DOE:	Department of Energy
EPA:	Environmental Protection Agency
FMLS:	First Multiple Listing Service
GIS:	Geographic Information Systems
HERS:	Home Energy Rating System
MLS:	Multiple Listing Service
NAHB:	National Association of Homebuilders

Summary

The construction industry has responded to the demand for more energy and resource efficient buildings through the adoption of voluntary green building programs that provide guidelines for construction projects wishing to reduce their environmental impact. These green building programs present the opportunity for those pushing beyond the status quo to receive increased recognition and market visibility; however, certification under these programs is not without an added cost. The added cost of certification varies by project, but building owners and builders must be able to justify this added cost through increased market recognition and sales and leasing prices. Given the relatively low recognition of a price premium for green certified residential properties by the real estate appraisal community and financial institutions, a need exists to demonstrate the added market recognition of these homes.

Analyzing a large dataset of residential properties sold in metropolitan Atlanta between 2007 and 2010, this research seeks to identify the sales premium associated with green building certification through the use of a hedonic regression pricing model. This model also accounts for the effect of other explanatory variables including location, time of sale, and housing characteristics and features, providing insight into those factors which have a significant impact on housing prices.

Chapter 1: Introduction

The construction sector presents a large opportunity to reduce society's energy consumption and environmental impact. As noted by the United Nations Environmental Program, buildings have a disproportionally large environmental footprint, "the buildings sector is the single largest contributor to global greenhouse gas emissions, with approximately one third of global energy end use taking place within buildings" (United Nations Environmental Program, 2011) . The United States exemplifies this issue, accounting for only 4.5% of world population but 19% of global energy consumption, with the energy consumed by buildings representing 41% of the U.S. total. Breaking this down further, energy use in residential structures makes up a majority of energy use attributable to the U.S. buildings sector at 22% of the nationwide total, Figure 1.

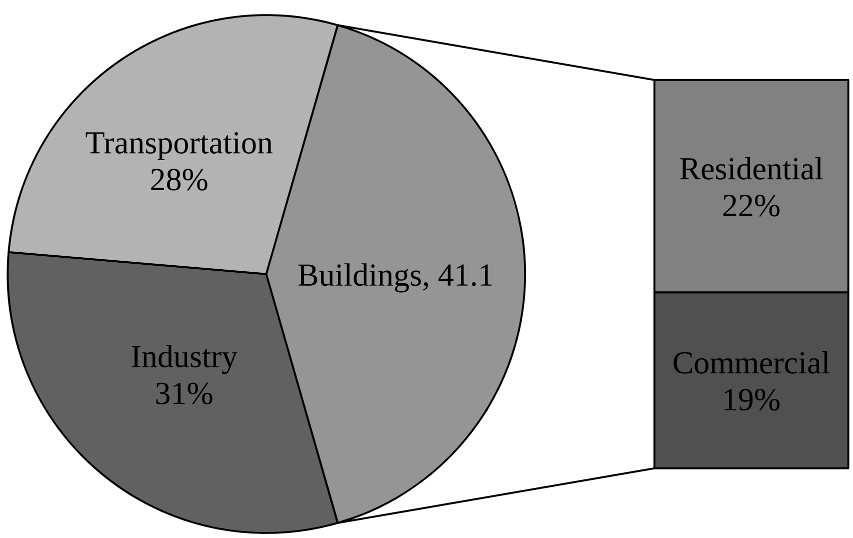


Figure 1 – United States energy consumption, 2011

Buildings also account for over a third of global resource consumption, and their construction and renovation generates 30 to 50% of solid waste in industrialized nations (United Nations Environmental Program, 2003).

Given the potential downside impacts of climate change and resource depletion, it is imperative that the construction industry deliver buildings that meet owner requirements while using less energy and natural resources. In response to this challenge, the construction industry has adopted voluntary green building programs that incentivize more efficient building practices and provide guidelines for construction projects wishing to reduce their environmental impact. Green building programs also present the opportunity for those pushing beyond the status quo to receive increased recognition and market visibility; however, certification under these programs is not without an added cost. In some cases the measures added to a project in pursuit of green building certification can add up to 15% of total construction costs. The added cost of certification varies by project, but building owners and builders must be able to justify these added expenses through increased market recognition and sales and leasing prices.

This research seeks to explore the effect of green building certification on residential sales prices for the Atlanta metropolitan area, over the period from 2007 to 2010. Analyzing a large dataset of residential properties in metropolitan Atlanta, including homes certified under the EarthCraft House green building program as well as a set of non-certified reference homes, this study seeks to determine if a sales premium exists for green certified homes through the use of a hedonic pricing model. This approach assumes that the individual characteristics for each home including EarthCraft certification, time of sale, location, and specific home characteristics (size, finishes, etc.) have an implicit value recognized in the final sale price of the home.

To develop this model information had to be gathered on homes sold during the study period including sales price, green building certification, and other characteristics thought to have potential impact on home value. A local real estate sales database and certification records for the EarthCraft House program provided the data necessary to develop this model, with additional information gathered from the U.S. Census and other sources. Geographic information system (GIS) and statistical analysis software were used to narrow an initial data set of over 36,000 homes to a set of 1,094 homes, 300 of which were EarthCraft certified. These tools also facilitated the determination of a final hedonic model assisted by linear regression of the considered housing characteristics. The final model resulting from this analysis quantifies the price impact of green building certification and determines those factors with a significant impact on home sales price.

Problem Statement

Green building programs recognize construction projects that have implemented best practices for sustainability and reduced their impact on the environment. To build a sound business case for participating in these programs, builders and developers must receive increased market value for certified properties to offset the added cost and complexity associated with certification. Through the development of a hedonic regression pricing model this study seeks to isolate the effects of green building certification on housing sales prices, in order to prove the hypothesis that a significant increase in sales price is associated with green certified housing.

Chapter 2: Background

Sustainability and the Built Environment

Policy makers, industry, and concerned citizens have realized the need to reduce the impact of built environment on the planet and to reduce the related energy consumption and emissions of carbon dioxide and other greenhouse gasses that contribute to global warming. Given the potential downside impacts of climate change and resource depletion, it is imperative that the construction industry deliver buildings that meet owner requirements while using less energy and resources. Buildings must be sustainable, meeting the needs of the present without compromising the ability of future generations to meet their own (United Nations. General Assembly, 1987).

Providing a definition of green building is difficult given the wide ranging goals of producing a sustainable built environment. According to a Morrison Hershfield report on the business case for green building in Canada, green buildings integrate environmental and social goals. There are the direct environmental benefits associated with reducing the building’s impact on the environment through reduced energy, material, and water consumption, but there are also the social benefits of an improved indoor environment for occupants and societal benefits related to sustainable development patterns that reduce commute times and vehicle miles traveled. The features incorporated into a green building seek to address the key issues of energy consumption, water consumption, material selection and consumption, and indoor environmental quality. Green building can be differentiated from conventional construction practices in that it produces buildings with improved indoor environments that have reduced environmental impacts (Luciuk M. , 2005).

Voluntary energy efficiency efforts and green building programs compliment mandatory regulations and financial incentive policies by providing opportunities for construction projects pushing beyond the status quo to receive increased recognition and market visibility. Under these programs building owners and developers commit to meeting increased performance standards which are established by government agencies or trade associations (Lee & Yik, 2004). These increased standards can apply to increased energy savings or take a more holistic approach including requirements for land development, community connectivity, materials, and indoor air quality.

A number of green building programs have been established since the emergence of eco-labeling programs for buildings in the early 1990s (Lee & Yik, 2004). These programs have been specialized for different target markets, with separate certification programs aimed at the commercial and residential building sectors. Additional specialized programs have been developed for the unique needs of different market segments, including schools, healthcare, retail, and multifamily residential among others. Building off of existing building code and regulation, programs tend to be administered at the national or regional level, with regional programs often including requirements based on the specific climactic conditions of a given location.

This research focuses on residential housing units certified under the EarthCraft House regional green building program. A summary of the requirements for EarthCraft House certification, and the features that differentiate certified homes from those built to the base building and energy codes follows.

EarthCraft House

Different areas of the country have developed local green building programs that hope to achieve the environmental and energy efficiency goals important to their specific regions. Started in the Atlanta metropolitan area as a partnership between the Greater Atlanta Homebuilders Association and the Southface Energy Institute in 1999, the EarthCraft House green building program provides certification to homes that meet increased performance standards that are targeted towards the environmental issues found in the southeastern United States. Since its inception EarthCraft has expanded to a suite of programs targeted at specific construction types, including single family, multifamily, community development, and light commercial, certifying over 24,000 homes and buildings to date. This study focuses on single family detached homes certified under the EarthCraft House program from 2007 to 2010.

For the study period, homes certified under the program had to meet 2006 International Energy Conservation Code requirements, receive ENERGY STAR Version 2.0 certification, and earn a minimum number of optional points tied to improvement measures in a number of different environmental impact areas. For comparison, homes built during the same period that were not certified should have been built to meet minimum building and energy code requirements, but code enforcement is often inconsistent and based on the experience levels and resources of code inspectors in individual municipalities.

EarthCraft House ensures homes built under the program meet minimum quality standards through code compliance, and goes a step beyond code with the requirement for ENERGY STAR certification. The ENERGY STAR program is a partnership of the U.S. Environmental Protection Agency (EPA) and Department of Energy (DOE) and provides increased performance standards for electronics, home appliances, lighting, heating and cooling equipment, water heaters and commercial and residential buildings. Started in 1996, the residential home labeling program has evolved through three versions, with increasing energy efficiency requirements for each program update. Version 1.0 established requirements for high efficiency HVAC equipment, construction details aimed at reducing air infiltration and duct leakage, and third party verification and performance testing to ensure that each home met program requirements. Version 2.0, introduced in 2006, added additional efficiency and third party testing requirements, including that homes demonstrate above code performance through a Home Energy Rating, commonly referred to as a HERS Rating. Given that the ENERGY STAR New Homes program serves as the energy performance standard for multiple residential green building programs including EarthCraft House, all of the homes in this study will have earned the ENERGY STAR label under Version 2.0 of the program and received a HERS Index as discussed below. Version 3.0, introduced in 2011, targets even higher savings goals with a more complete building science approach and increased quality control guidelines (Raskin, 2010). No homes in this study were certified under Version 3.0 of ENERGY STAR.

Homes earning the ENERGY STAR label under Version 2.0 of the program demonstrate minimum energy performance of at least 15 to 20 percent better than homes built to the

2004 International Energy Conservation Code, depending on climate location (ENERGY STAR). Note that the commercial label is based on post-occupancy energy consumption, whereas the residential label is based on projected savings from a modeled Home Energy Rating (HERS Rating). This Home Energy Rating provides a HERS Index which scores the performance of the rated home on a 100 point scale. A new home built to the reference code would receive a HERS Index of 100, whereas a with net zero energy consumption would receive a HERS Index of zero. An ENERGY STAR home must score 85 or below, 80 or below in northern climates (RESNET). The HERS index can function as a yard stick by which consumers can compare the projected energy use of homes with different features that affect energy consumption, similar to the way in which cars are rated for gas consumption via miles per gallon. An internal study conducted by the Southface Energy Institute found that EarthCraft certified homes had an average HERS index of 72, meaning that the average EarthCraft home is projected to perform 28% better than code.

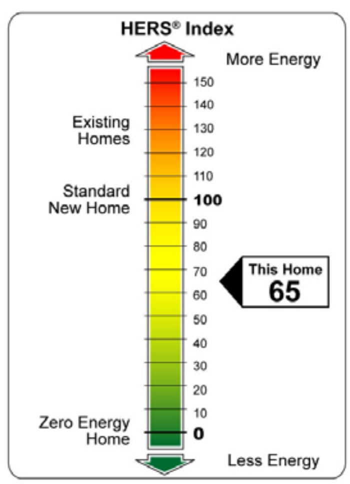


Figure 2 – HERS Index (RESNET)

The ENERGY STAR program also requires two quality insurance site inspections by a qualified Home Energy Rater (HERS Rater). The first inspection, a pre-drywall inspection, occurs mid-construction after the installation of air sealing measures and insulation but before the installation of interior finish surfaces. During this inspection, the HERS Rater conducts a thorough examination of the home to ensure that the required air sealing measures have been completed and that the insulation installation meets minimum performance standards. The second inspection takes place once the home has been completed and includes two separate performance tests – blower door and duct pressurization tests. A blower door test uses a calibrated fan to measure air infiltration levels for the whole house, and a duct pressurization test uses a calibrated fan to test the leakage rate in air ducts. These steps ensure that the home will perform as intended and provide additional quality control to builders participating in the program.

Beyond the basic code and ENERGY STAR certification requirements, homes wishing to earn EarthCraft certification during the study period were required to earn a minimum level of points in 10 environmental impact categories.

- Site Planning
- Construction Waste Management
- Resource Efficiency
- Durability and Moisture Management
- Indoor Air Quality
- High Performance Building Envelope
- Energy Efficient Systems

- Water Efficiency
- Education and Operations
- Innovation

Each of these categories contained a number of optional measures with different point weightings, and a project had to earn a minimum of 100 total points through the implementation of these measures in order to earn basic EarthCraft certification, with 150 points earning gold level certification and 200 points earning platinum certification (Southface Energy Institute, 2008).

Homes that earned EarthCraft certification can be differentiated from homes built to base code requirements in a number of ways including third party quality assurance inspections and testing, ENERGY STAR certification, a HERS index to project annual energy consumption potential, and various environmental measures required to earn certification.

Atlanta Residential Market

Atlanta today is the largest city in the southeast and a major distribution and transportation hub, hosting many corporate offices, with specializations in service sectors, technology, health, education and construction industries. With a moderate climate, superior airport connections, and national trends towards an older population relocating to the Sunbelt states, Atlanta job and population growth has been near or at the top of the U.S. for the last 30 years. The metropolitan area has few natural boundaries to growth, with over 50 county and municipal governments, and has sprawled widely from its urban core with a majority of suburban growth occurring along an arc north of the city.

The metropolitan Atlanta area consists of 10 core and 10 external counties. The core counties include Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry and Rockdale counties, as well as the City of Atlanta in Fulton County. The external counties include Barrow, Bartow, Carroll, Coweta, Forsyth, Hall, Newton, Paulding, Spalding and Walton counties (Atlanta Regional Commission, 2011). The Atlanta Regional Commission (ARC) serves this area, functioning as the regional planning and intergovernmental coordination agency for the core 10 counties and publishing additional data on the external 20 counties. Given the availability of data from ARC, this study focuses on this 20 county metropolitan area.

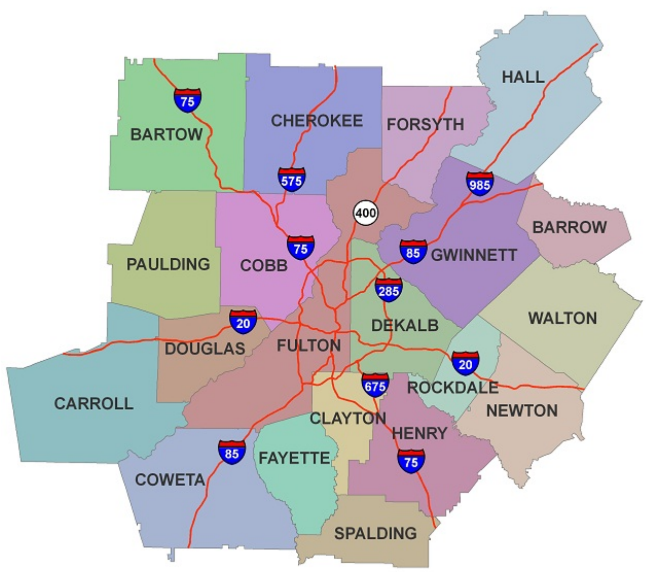


Figure 3 – 20 county metropolitan Atlanta area (Atlanta Regional Commission)

As one of the fastest growing cities in the nation, Atlanta has averaged over 3% growth per year since 1990. Looking to population numbers from the 2000 and 2010 census, the metropolitan area grew by 24% with growth concentrated in the region's core counties. The core 10 counties contain two thirds of the region's population with a large amount of suburban growth taking place along the northern arc including Gwinnet, Fulton, Forsyth, Cherokee, and Cobb counties, as well as Paulding and Henry Counties, Figure 4 (Atlanta Regional Commission).

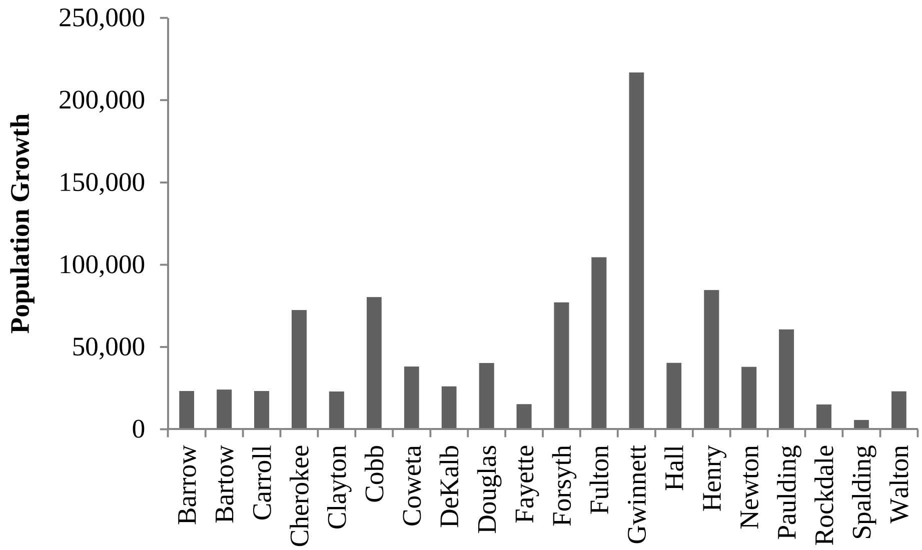


Figure 4 – Atlanta population growth by county 2000 to 2009

The construction of single family new homes further illustrates these trends, with growth concentrated in north and south Fulton, east Gwinnett, west Paulding, and Henry counties, Figure 5.

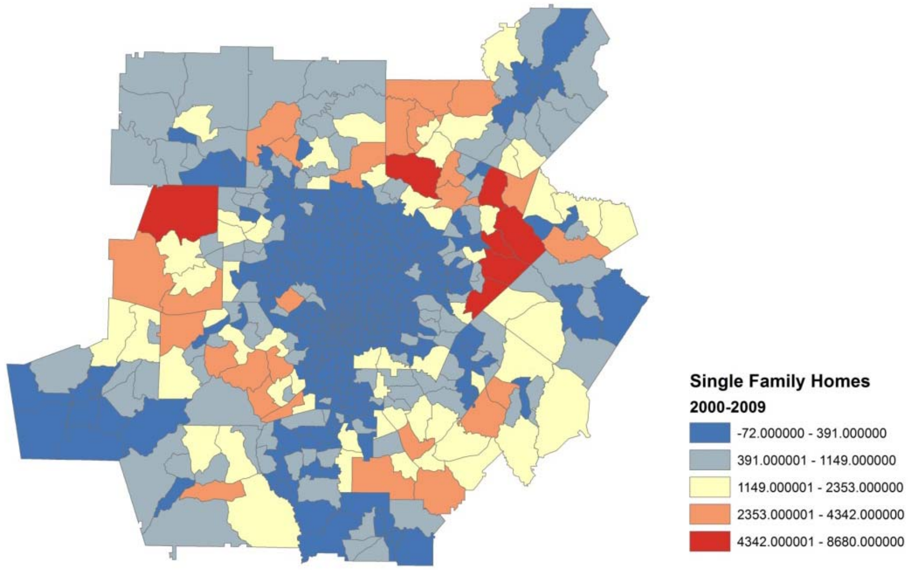


Figure 5 – Single family new home construction 2000 to 2009

The period from 2000 to 2010 represented a period of strong growth in population and housing for the Atlanta area, but this growth was neither consistent nor sustained. Focusing on the period for this study, 2007-2010, the effects of the global recession which began in late 2007 can be observed in the housing and unemployment numbers for the metropolitan area. The recession hit Atlanta particularly hard, generating increased levels of unemployment and a reduced number of housing starts. Pre-recession between four and five thousand new homes per month were being built in the Atlanta metropolitan area, and the unemployment rate was below 5%. Housing starts plummeted in mid-2007 to less than 20% of their peak numbers, and unemployment rose to over 10%. Given the dependence of the Atlanta population on the construction industry for jobs, this presented a compounding problem. The effects of the recession and the attempts of the Federal Reserve to alleviate the problem through reduced interest rates are illustrated in Figure 6.

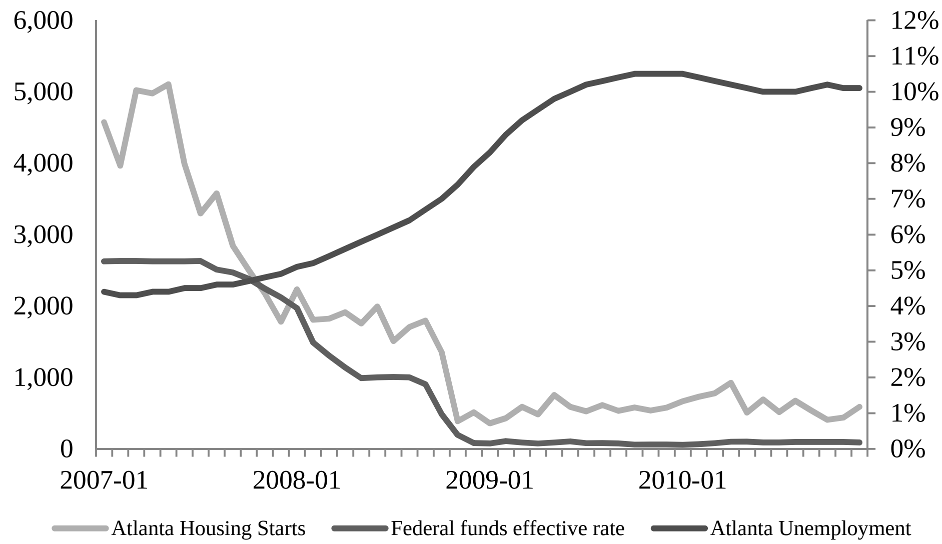


Figure 6 – Financial indicators, 2007-2010

As this study covers home sales during a period of great upheaval in the Atlanta housing market, the performance of EarthCraft certified housing is of particular interest. Determining whether green certified homes provide a good return on investment to builders and developers and how these homes perform in the market against comparable properties provides valuable information to real estate and construction professionals considering green building certification as a hedge against market volatility.

The Cost and Value of Green Building

A majority of the research investigating the valuation of green building certification has focused on the commercial sector and the benefits green buildings present to private investors through increased sales prices, rental rates, or rental occupancies; however, the basic findings and research models from these studies can be applied to the costs and home values in the residential sector. Morrison Hershfield's report on the business case for green building in Canada breaks down the economic issues related to green building into seven categories:

1. Direct capital costs: costs associated with the original design and construction of the building;
2. Direct operating costs: total costs of building operation, including energy use, water use, maintenance, waste, insurance, taxes etc. over the entire building life or the specified time horizon of the study;
3. Life cycle costing: the method of combining capital and operating costs to determine the net economic effect of an investment;
4. Productivity effects: dollar value related to changes in occupant productivity relative to a typical / conventional building (only for buildings where productivity can be equated to monetary value);
5. Property values and absorption rates: a key factor for speculative developers who cannot necessarily directly capture operating cost and productivity savings;
6. Other indirect or intangible benefits such as increased retail sales and risk reduction; and
7. External or tertiary economic effects, such as reduced reliance on infrastructure (sewers, roads, etc.), reduced greenhouse gases, reduced health costs, etc., that are not readily captured by the private investor (Luciuk M. e., 2005)

For the purposes of this study, it is necessary to redefine these economic issues for the residential sector from the perspective of those producing and consuming the housing product. The builders and developers producing housing units will be concerned with the direct capital costs associated with earning green building certification, the increased or perceived sales value associated with green certified housing, and the value proposition that can be made to potential homeowners. From the perspective of the housing consumer this value proposition includes reduced operating and lifecycle costs, an improved indoor environment, and reduced exposure to risk associated with a higher quality product. Potential home buyers of would also be concerned with the added value of green certified housing for future resale.

Incorporating the features that differentiate green buildings from conventional construction does not come without an added cost, both in materials and professional design. As Eicholtz, Kok, and Quigley pointed out in their analysis of the financial performance of green office buildings in the United States, “For developers to be prepared to commit money and resources to green buildings, they need to be confident that there will be a market for their product. If there is no premium, why go to the trouble and expense of creating a premium product” (Eickholtz, Kok, & Quigley, 2009) ? These added costs must be recouped in order for green building to present a value proposition to builders and developers.

As previously mentioned, a majority of the economic analysis of green building has been focused on the commercial sector. These studies show that stakeholders across the construction industry share the general perception that green building is more expensive than conventional construction; however the research does not support such a negative perspective. The added cost of green building certification varies based on the project, but on average certification adds only 2% to project costs and among the studies reviewed the cost of green certification often fell within the range of cost for conventional construction (Luciuk M. e., 2005).

Limited research exists covering the added capital costs of green certification for residential projects. Much of the data available focuses on single project case studies and does not review costs across large sample sets. Based on these case studies, the added cost of green certification varies widely by project. Case studies reviewing the construction of multiple affordable housing units built to earn the ENERGY STAR for New Homes label showed cost premiums ranging from $700 to $5,000 dollars per home, equating to 0.7 to 3.1% of total construction costs (ENERGY STAR, 2009). Another case study completed by the National Association of Home Builders (NAHB) Research Center showed an added cost premium of 17% associated with certification for a market rate single family home built in Lancaster, Pennsylvania which earned silver certification under the National Green Building Standard (NAHB Research Center, 2009). This issue of increased costs may be one of perception. A survey conducted by McGraw Hill Companies at the NAHB International Builder Show in 2011, showed that builder's opinions about the increased cost of green building may be changing, with the added cost estimated at 11% in 2006, 8% in 2008, and 7% in 2011 (NAHB, 2012).

Building homes that earn green building certification may cost more than building homes using traditional construction techniques, but the level of added cost varies widely and more in depth research is required in this area. Studies examining larger pools of homes, such as those completed in the commercial sector, would provide builders and developers with more information on the cost of pursuing green building certification. Based on the case studies reviewed the added cost varies with the type of housing, and the certification program pursued, as well as the certification level. Other factors such as location and project team experience should also be taken into account. Experienced project teams that practice integrated design and consider the inclusion of green features and objectives early in the design and construction process may be able to build green at zero added cost (Martin, Swett, & Wein, 2007).

Pricing Models

In the housing market, homebuyers provide demand for a housing product, and homebuilders and developers attempt to meet this demand by building homes that they believe will appeal to potential homebuyers. The housing market is segmented in that there are different types of homes that seek to attract different types of homebuyers. Typically a young first time homebuyer will be in the market for a different type of home than that of a middle aged move up buyer with a family. Since external factors out of the control of homebuilders and developers influence housing demand, these producers of housing product seek to build homes that will deliver supply that meets the demand of a particular market segment at a price that consumers in that segment are willing to pay. Understanding the different factors that affect housing price would give housing producers a competitive advantage in the market.

Regardless of how one thinks about the different components that influence housing prices, it can be agreed that housing is a heterogeneous good with multiple factors that influence final sales price. Both quantitative (floor area, lot size, number of stories, age, etc.) and qualitative (condition, neighborhood quality, architecture, etc.) factors influence the sales price of residential homes (Raslanas, 2006). The factors that determine price may also be thought of as interior (physical structure of the home, the neighborhood where the home is located, market conditions, and housing policies) and exterior (physical, social, and cultural elements, as well as access to nearby job centers and urban facilities) (Keskin, 2008).

The understanding that housing prices are dependent on various factors that may differ by market area and market segment is vital to creating a robust pricing model that can accurately assess the influence that individual components have on the final sales price. Some past studies that have sought to assess the value of residential green building programs in the housing market have failed to include this fundamental approach, comparing the average price of certified homes to those that were not (Earth Advantage Institute, 2011) and (Matthews, 2010). These studies failed to recognize the multitude of factors that influence final sales price. Sales analyses and statistical models that more adequately account for the factors that influence housing value will be discussed in the following sections. These approaches can be used both to determine the factors that influence housing price and to assign value to individual factors.

Sales comparison approach

Real estate professionals utilize one of the most basic pricing models for almost all sales transactions. Ideally for home sales where the property will be used as collateral to secure mortgage financing, real estate appraisers conduct a comparative sales analysis in order to assess the value of the property for sale and ensure that the home value is adequate to secure the amount of the mortgage loan. Using this approach, a real estate appraiser assesses the value of a particular property based on the recent sales value of similar properties. In choosing a similar property, real estate appraisers must evaluate the factors that they believe affect value and make adjustments to the appraisal based on differences between the home in question and the comparable properties chosen.

To apply the sales comparison approach it is necessary to have adequate information about the comparable sales, including sales price and influencing factors. In general these include 10 basic elements:

1. Real property rights conveyed
2. Financing terms
3. Conditions of sale
4. Expenditures made immediately after purchase
5. Market conditions
6. Location
7. Physical characteristics (size, construction quality, condition, etc.)
8. Economic characteristics (expense ratios, lease provisions, etc.)
9. Use (zoning classification)
10. Non-realty components of value

An appraiser will follow a systematic procedure when using the sales comparison approach – first researching sales transactions for similar properties, second verifying the accuracy of sales data gathered, third selecting sales units for comparison (typically total sales price or price per square foot in the case of single family residential properties), fourth identifying differences between the subject property and the comparative sales and making adjustments to reflect these differences, and fifth reconciling the values reached by the analysis into a single or range of values for the subject property (Appraisal Institute, 2001).

With relatively few homes in the current residential real estate market that have earned green building certification, real estate professionals find making sales comparisons for green certified homes difficult. Homebuilders and homeowners often express frustration that there is not currently a formalized approach in the industry to assessing the added value associated with green building certifications and the features incorporated into homes in order to earn these labels. Real estate professionals most often use multiple listing services (MLS) to identify comparative sales and the data necessary to complete appraisals. These databases, often regional in scale, include the asking prices of homes on the market, recent sales prices, and the attribute data for the relevant homes. In an effort to raise industry awareness and allow for sales comparisons of green certified homes environmental advocates within the real estate profession have pushed for the inclusion of green certification labels in MLS databases with mostly successful results. Inclusion of these attributes in MLS databases does not provide a complete solution to this problem, as real estate professionals must be educated on the features and benefits of green building certification programs and be savvy enough to enter and pull information from MLS databases on green certified homes accurately. The Atlanta First Multiple Listing Service for example, which is a major source for the data used in this study, includes attribute categories for both HERS index and green building certification, but a review of the available data shows that these attribute categories are often mislabeled, if used at all.

The real estate appraisal community has made strides in educating and informing its members on the principles of green building and methods to value green building certifications and individual green features through the work of professional organizations. The Appraisal institute released a *Residential Green and Energy Efficiency Addendum,* included in the appendix, which can be used to appraise green properties or those properties that include major environmental or energy efficiency upgrades. This form includes information on energy efficient items including individual features and green building certifications, renewable energy, transportation and site related issues, and any green or energy efficiency incentives that may factor into the final value of the home (Appraisal Institute, 2011). This addendum is a first step in establishing industry standards for valuing green building certifications and measures, but further work is needed for this approach to make inroads in the Atlanta market.

Paired Data Analysis

In real estate markets in other areas of the country where green building certification programs have reached higher levels of market adoption, local MLS databases provide more robust information on green certified homes, making accurate comparative sales analysis possible and allowing for more detailed studies on the value of these labels. A study published by the Earth Advantage Institute in 2009 analyzes the value of third party green certification labels in the Portland, Oregon and Seattle, Washington real estate markets. The authors used a paired data analysis to compare the sales prices of certified to non-certified homes. A paired data analysis assumes that when two properties are essentially identical, a single characteristic can be isolated to determine that characteristic's effect on sales price (Appraisal Institute, 2001). Comparing 92 certified properties to comparable properties, with from two to seven comparable properties for each certified home, the study methodology defined comparable residences as those:

- sold with a closing date no more than 6 months prior to the closing date of the subject property
- located within the same neighborhood or sub-neighborhood
- constructed in a similar style based on photographs and staff determination
- constructed to the same degree of quality (e.g., design and materials)
- in the same age range (built within 10 years prior and 5 years after the subject home)
- approximately the same size (within a range from 15% smaller to 5% larger in square feet)
- approximately the same value (with a final sales price from 20% below to 10% above the sales price of the subject home)
- built with no distinguishing green features

Using this approach, the authors found that certified homes held a 3 to 5% sales premium over non-certified homes, and that these homes remained on the market for 18 days less than non-certified homes (Griffin, 2009).

Regression Analysis

For data with large variability, such as the large variance in home prices across the metropolitan Atlanta region, regression analysis can be used to determine which explanatory variables have a relationship with the dependent variable, home sales price, and the significance of that relationship if one exists. The basic form of this approach approximates a linear relationship between the dependent variable, y, and the explanatory variable, x, for a data set of paired observations:

$$y = a_0 + a_1 x + e$$

Where a_0 and a_1 are coefficients representing the y-axis intercept and the slope and e is the error or residual between the model and observations. The best fit line for this relationship minimizes the sum of the residual error terms. To evaluate the fit of a linear regression model, further analysis can be completed to determine the coefficient of determination, r^2, which approximates 1 when the model explains 100% of the variability in the observed data. For example, an r^2 value of 0.94 would indicate that the model explains 94% of the variability in the observed data.

In situations where the dependent variable is believed to be a linear function of multiple explanatory variables, such as housing values which have been shown to be the result of multiple factors, multiple regression can be used. This approach approximates a relationship between the dependent variable, y, and multiple independent variables, $x_1, \ldots, x_n$, for a data set of observations:

$$y = a_0 + a_1 x_1 + \ldots + a_n x_n + e$$

Where a_0 is the coefficient representing the y-axis intercept, $a_1, \ldots, a_n$ are constant coefficients, and e is the error or residual between the model and observations. When using multiple regression the adjusted coefficient of determination, adjusted r^2, should be used, as it accounts for the effects of the multiple explanatory variables on the model fit (Chapra, 2003).

Raslanas used both linear and multiple linear regression in their analysis of the factors affecting the price of housing flats in southeast London and Vilnius. From the literature, "[regression] analysis allows defining relations between two or more interdependent factors so that the value of one factor may be defined with a certain probability when the value of another factor is known" (Raslanas, 2006) . Single linear regression was used to determine the factors that had a significant relationship with housing prices, and once a group of factors was determined a multiple regression model was completed to determine housing prices based on these factors. In order to simplify the analysis, modeling of housing data for both southeast London and Vilnius was completed at the neighborhood level. The multiple linear regression models completed in this study showed varying levels of fit, but high levels of explanation were found for individual neighborhoods, ranging from $r^2 = 0.67$ to $r^2 = 0.89$.

Hedonic Regression

Hedonic regression provides another statistical approach to determining housing prices based on a set of measured characteristics. When developing a hedonic model for housing prices, the price in the market is defined as "the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (Rosen, 1974) . In other words housing is a collection of its individual parts, or influencing factors, each of which have individual value which as a whole are recognized by the sales price in the marketplace.

This hedonic model relates the dependent variable, sales price, to the explanatory variables representing individual characteristic categories using a vector function:

$$P = \beta_0 + \beta_1 X_1 + ... + \beta_n X_n + e$$

where P is the vector of transaction prices, $X_1 ... X_n$ are the vectors of variables for individual characteristic categories, β_0 is a constant, and e is the error term. Past studies have broken down housing prices into characteristic categories such as property, socio-economic, neighborhood quality, and location characteristics. Individual observations in each category make up the vector variables used in the model (Keskin, 2008). This modeling approach is routinely used in order to develop pricing models for real estate transactions and can be applied over market areas of varying size. Isolating green and energy efficiency labels, as well as specific features, associated with individual properties, hedonic modeling has been applied to determine the price premium associated with energy efficiency, green building, and individual energy upgrades in both the commercial and residential sector.

Eichholtz, Nok, and Quigley completed an analysis of the financial performance of green certified office buildings in the United States, using a hedonic approach. Cross referencing the CoStar commercial office database with certification registries from the US Green Building Council and EPA's ENERGY STAR program, rental data for 893 office buildings was collected and compared to a sample of comparable buildings that were within a ¼ mile radius of each certified property. The hedonic model derived for this study took the form of:

$$logR_{in} = \alpha + \beta_i X_i + \sum_{n=1}^{N} \gamma_n c_n + \delta g_i + \varepsilon_{in}$$

where R_{in} is the rent per square foot for office building i in cluster n, X_i is a vector of hedonic characteristics including the percentage increase in service sector employment for the Core Based Statistical Area containing building i, c_n is a dummy variable for cluster location, and g_i is a dummy variable for LEED or ENERGY STAR certification. This study found rent premiums of 3 to 6% and a sales price premium of 16% for green labeled buildings, a significant benefit to the building owners and incentive for those looking to develop green office space (Eickholtz, Kok, & Quigley, 2009).

A similar study by Kok and Kahn, focused on the green premium for residential properties, developing a hedonic model for home sales in California. The researchers compared 4,231 homes certified under the LEED for Homes, ENERGY STAR, or California green building program Build it Green to a control sample of 1.6 million comparable homes. The hedonic model derived for this study took the form of:

$$log\left(R_{ijt}\right) = \alpha green_{it} + \beta X_i + \gamma_{jt} + \varepsilon_{ijt}$$

where R_{ijt} is the sales price for home i in cluster j in quarter t, X_i is a vector of hedonic characteristics for home i, and γ_{jt} is a vector of dummy variables for zip code and quarter of sale. The hedonic characteristics determined to have a significant impact on sales price included dwelling size, the number of bed and bathrooms, and the presence of a garage or carport. The study found a significant sales premium of 9% (+/- 4%) for green labeled homes (Kok & Kahn, 2012).

Researchers from the U.S. Department of Energy's Lawrence Berkley National Lab (LBNL) completed a market study using hedonic analysis to determine the added sales premium associated with residential photovoltaic solar panels in California. The study utilized a large dataset of California homes sold from 2000 to 2009. The hedonic model derived for this study took the form of:

$$\ln(P_{itk}) = \alpha + \beta_1 T_t + \beta_2 N_k + \sum_a \beta_3 X_i + \beta_4 PV_i + \varepsilon_{itk}$$

where P_{itk} is the home sales price for transaction i in quarter t in census block group k, T_t is the quarter in which transaction i took place, N_k is the census block group where transaction i took place, X_i is a vector of hedonic characteristics for the home in transaction i, and PV_i is a dummy variable for the installation of photovoltaic solar panels for the home in transaction i. The hedonic characteristics determined to have significant impact on home sales price included house age, house size, lot size, and elevation relative to surrounding homes as a stand in for scenic views. The study found significant price recognition associated with the installation of these systems. "The effects range, on average, from approximately $3.9 to $6.4 per installed watt (DC) of PV, with most coalescing near $5.5/watt, which corresponds to a home sales price premium of approximately $17,000 for a relatively new 3,100 watt PV system (the average size of PV systems in the study)" (Hoen, Wiser, Cappers, & Thayer, 2011) .

These three studies focused on identifying the sales or rental premium associated with green labels and renewable energy found a statistically significant increase in sales price and rental rates, and while each study used different sets of sample data, a common approach can be found to determining the hedonic models used in each study. All three studies included explanatory variables for the following four factors:

1. Green certification or the presence of green features for the property in each real estate transaction
2. Location of real estate transaction
3. Time of real estate transaction
4. Hedonic characteristics for the property in each real estate transaction

Each hedonic model included a vector of dummy variables to indicate whether a property had received a green certification or included a green feature of significance, the presence of photovoltaic solar panels for example in the LBNL study. Location was considered in all three studies based on zip code, census block group, or radial distance from each green certified property. Both residential studies included a time of sale for the real estate transaction in the form of a dummy variable for quarter of sale. As stated by Kok and Kahn considering both the location and time of sale acts as a stand in for a large subset of market data, "This rich set of fixed effects allows for local housing market trends and captures the value of time-varying local public goods, such as crime dynamics or the growth or decline of a nearby employment district" (Kok & Kahn, 2012) . Finally all studies determined a set of hedonic characteristics for each building that had a significant impact on sales price or rental rates. These characteristics tend to include size, finishes, and other factors that demonstrate value to the consumer when compared to other properties without these features.

Chapter 3: Methodology

Sample Area

Given that EarthCraft house originated in the Atlanta metropolitan area, it is natural to select this area as the focus for this study. Although it is not possible to entirely capture the real estate market for a large city like Atlanta, choosing a large sample area including the core and exterior counties approximates the real estate market for the Atlanta metropolitan area. This study includes home sales for the 20 county metropolitan Atlanta area including Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry, Rockdale, Barrow, Bartow, Carroll, Coweta, Forsyth, Hall, Newton, Paulding, Spalding and Walton counties, see Figure 3. The availability of additional data from the US Census and Atlanta Regional Commission also influenced the boundary for the sample area.

Sample Data

FMLS and EarthCraft House Certification Records

Once the sample area had been defined, sample data was selected for the study that included both EarthCraft certified and comparable reference homes from the chosen sample area. Southface Energy Institute administers the EarthCraft House program and has a database containing records for all homes certified under the program since its inception in 1999. This database provided a pool of homes for comparison against non-certified homes in the Atlanta marketplace. The Atlanta First Multiple Listing Service

(FMLS) database provided both a pool of non-certified homes for the comparison, including sales and attribute data for home sales in the sample area. Additionally, the homes from this database were cross referenced against those from the EarthCraft database in order to provide attribute information and sales price records for the certified homes. Given the availability of data from FMLS, this study plans to focus on homes sales between 2007 and 2010.

Based on the study area and time period outlined above, the Atlanta FMLS database provided a potential pool of 36,232. Culling out homes with incomplete attribute data produced a data set of 13,085 homes. The attribute data for the selected homes is shown in Table 1.

Table 1 – Attribute data provided by Atlanta FMLS

Attribute	Data Type
Street Address	Text
Zip Code	Text
City	Text
County	Text
Sales Price	Numerical
List Price	Numerical
Square Footage	Numerical
Sales Price per Square Foot	Numerical
Total Half Baths	Numerical
Total Full Baths	Numerical
Total Bedrooms	Numerical
Number of Stories	Numerical
HERS Index	Numerical
Closing Date	Numerical
Tennis Court	Binary
Certified Professional Homebuilder	Binary
Year Built	Categorical
Water Source	Categorical
Subdivision	Categorical

Table 1 (continued)

Attribute	Data Type
Home Style	Categorical
Sewer Type	Categorical
Pool	Categorical
Neighborhood	Categorical
Elementary School	Categorical
Middle School	Categorical
High School	Categorical
Green Building Certifications	Categorical
Lot Size	Categorical
Basement Description	Categorical
Bedroom Description	Categorical
Dining Room Description	Categorical
Exterior Description	Categorical
Façade Description	Categorical
Interior Description	Categorical
Kitchen Description	Categorical
Laundry Description	Categorical
Lot Description	Categorical
Master Bath Description	Categorical
Parking Description	Categorical

The attribute data from Atlanta FMLS came in multiple forms: text, numerical, binary (1 for an attribute being included in a home and 0 if not), and categorical where a series of options described specific information about each home. The database also included information on whether each home had received green building certification or a HERS Rating, but consistent with the lack of awareness and education of green building in the real estate industry previously discussed, it was found that this data was inconsistent and therefore not reliable for inclusion in this study. Instead, the homes data from the FMLS database was cross referenced with EarthCraft House certification records.

The EarthCraft House certification records provided a pool of 1,597 potential home for the study period and area. Cross-referencing these homes with those provided by the Atlanta FMLS database produced 365 matches and added the attribute data outlined in Table 1 to each of these EarthCraft certified homes, Figure 7.

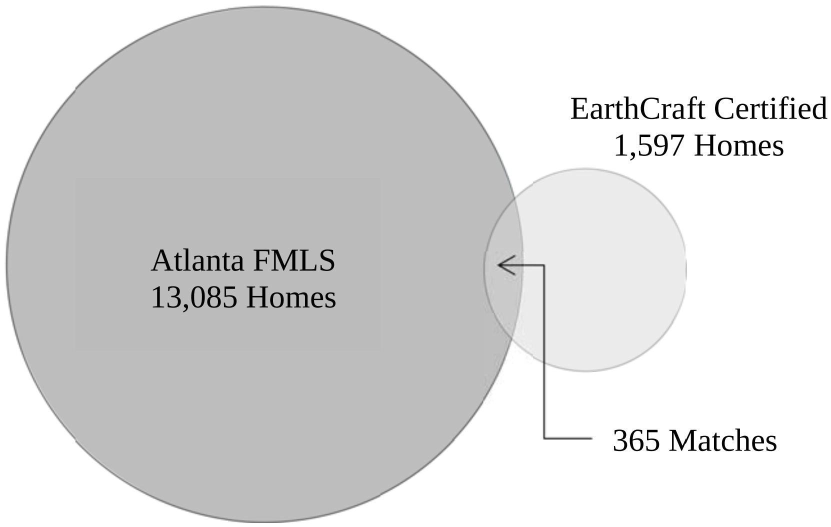


Figure 7 – Cross reference of Atlanta FMLS and EarthCraft certified homes

Removing outliers

In order to remove the influence of very large or expensive homes, outliers for both sales price and home square footage were removed based on the 95% of the data contained within two standard deviations of the mean, Figure 8 and Figure 9 .

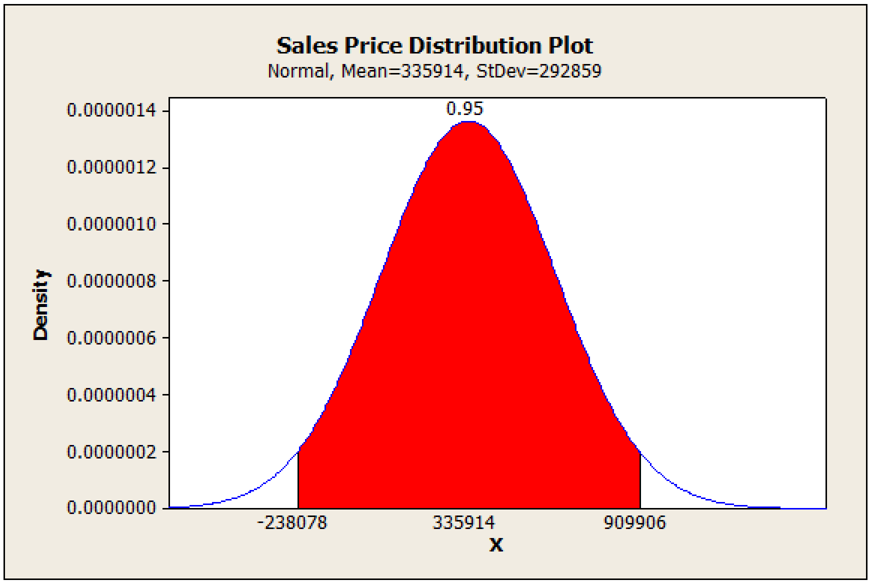


Figure 8 – Sales price distribution plot

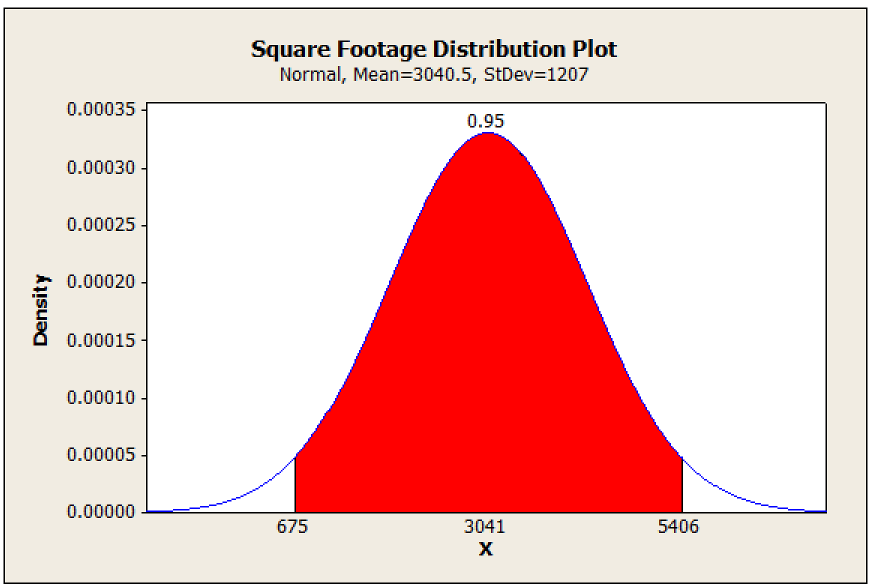


Figure 9 – Square footage distribution plot

Based on this analysis, only homes at the high end of the distribution for sales price and square footage were removed, those homes with sales prices above approximately 910,000 and with areas above approximately 5,400 square feet. This data cleaning left 12,309 homes, of which 343 are EarthCraft House certified homes.

Supplementing Categorical Data

Given the large amount of categorical data provided by the FMLS database and the difficulty of constructing a hedonic regression model with categorical data, other sources of numerical data were sought in order to account for variations in the local real estate market based on location and time of sale.

Data from the 2010 U.S. Census was added to the data set of 12,309 homes through the use of ArcGIS GIS software. Each home was geocoded within the software based on its address, locating each home in its true physical location. A map of 2010 census tracts was then overlaid such that the appropriate census tract and associated data could be assigned to each home, Figure 10.

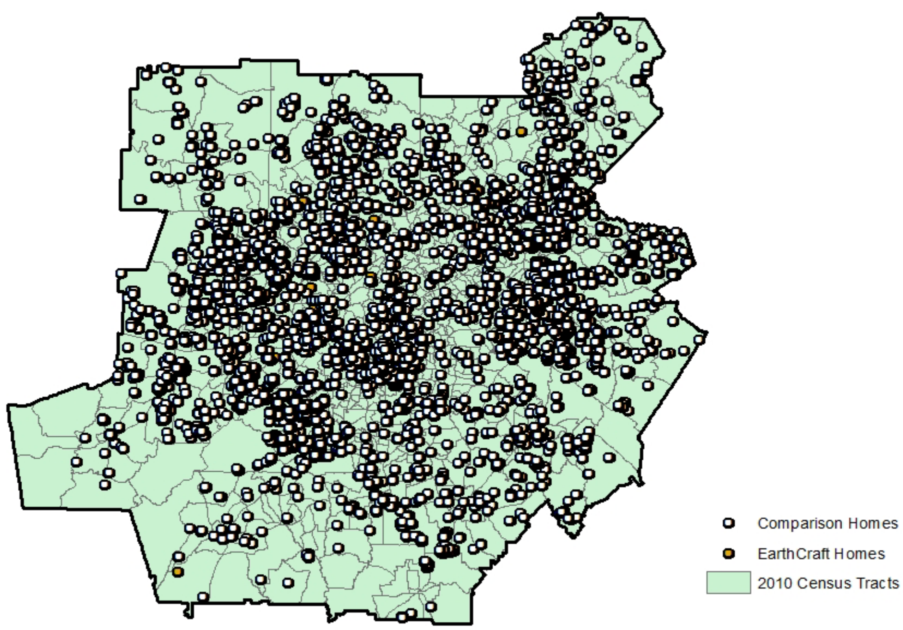


Figure 10 –Data set map with 2010 Census Tracts

The location specific attribute data from the 2010 Census is shown in Table 2. All data provides numerical values.

Table 2 – Attribute data provided by 2010 U.S. Census

White, One Race (%)	Poverty Rate All People (%)	Single Family '09 (%)
Black, One Race (%)	Housing Units '09	Single Family '00
American Indian (%)	Housing Units '00	Single Family Change '00-'09
Asian-American (%)	Housing Units Change '00-'09 (%)	Multifamily '09
Native Hawaiian or Pacific Islander (%)	Households '09	Multifamily '09 (%)
Two or More Races (%)	Households '00	Multifamily '00
Hispanic/ Latino (%)	Occupied(%) '09	Multifamily Change '00-'09
Total Housing Units	Occupied(%) '00	Mobile Homes '09
Total Occupied Units	Household Size '09	Mobile Homes '09 (%)
Total Vacant Units	Household Size '00	Mobile Homes '00
Mean Commute Time (Minutes)	Single Family '09	Mobile Home Change '00-'09
Median household income (dollars)		Unemployment (%)

Additionally, financial data thought to have potential impacts on home sales price was added based on sales closing date. The time specific financial attribute data is shown in Table 2. All data provides numerical values.

Table 3 – Financial attribute data

Unemployment
Federal Funds Interest Rate
Consumer Price Index
Atlanta Total Housing Starts
Atlanta Single Family Housing Starts

School ranking information was also added to the model, as the quality of school systems is often perceived to have a large impact on home values. Using a report from the Georgia Public Policy foundation, the 2010 statewide rank of the high school for each home was determined as a stand in for school quality (Georgia Public Policy Foundation, 2010).

Addressing Location Effects

Use of the GIS software to examine sales price and EarthCraft Certification as a function of location, Figure 11and Figure 12 , revealed that both measurements were clustered and did not follow a random distribution across the study area. Sales price distribution followed expected patterns given the makeup of the Atlanta area, with average sales prices of over $550,000 concentrated on the north side of downtown Atlanta between interstates I-75 and I-85 along the Georgia Highway 400 corridor extending from the Ansley Park neighborhood, up through Buckhead, to the Roswell area. Another pocket of high average sales prices is located on the south side of the metro area in Tyrone and Peachtree City. These neighborhoods and cities are commonly known as affluent areas. The distribution of EarthCraft House certification does not follow this pattern but extends from southwest to the northeast of the metro area, with large developments in Douglasville, in town Atlanta, and Gwinnett County. Given these nonrandom distributions and the fact that no EarthCraft certified homes were built across large parts of the metro Atlanta area, the initial data set was trimmed based on location.

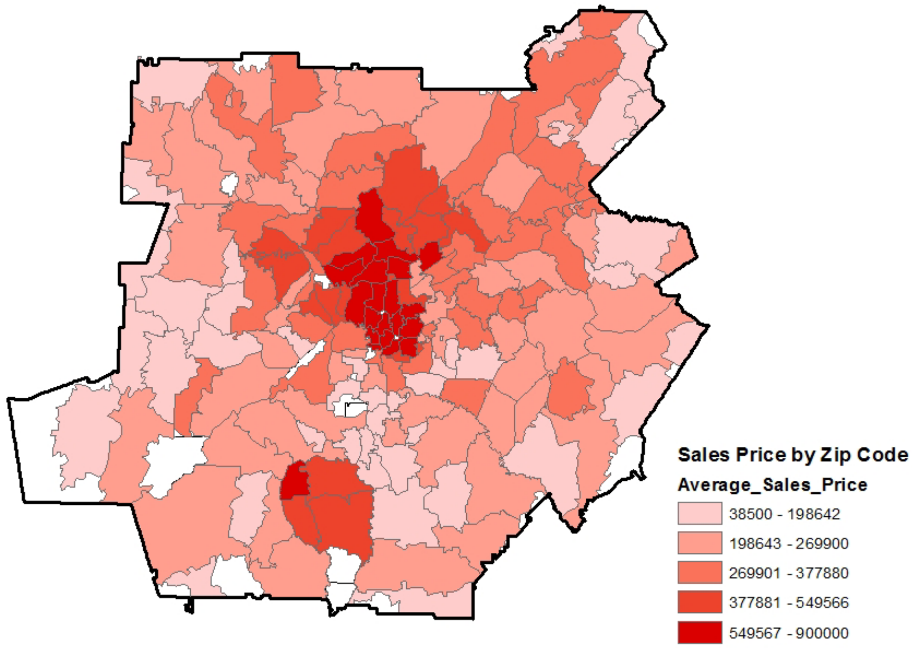


Figure 11 – Sales price distribution by zip code

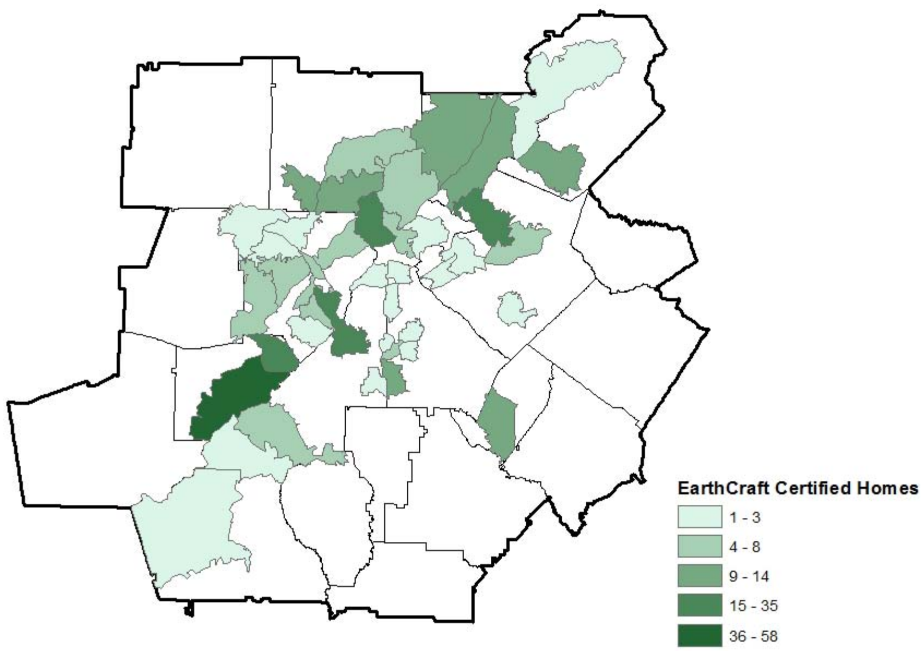


Figure 12 – EarthCraft House certification distribution by zip code

The literature review of other studies which used hedonic pricing models to identify the sales or rental premium associated with green labels and renewable energy found home location to be a major factor of sales price. Based on the reviewed studies, census block group was chosen as a location variable for the given home sales data, as it was the smallest available geographic boundary and a good stand in for neighborhood. From the LBNL study determining the price premium for photovoltaic solar panels,

> A census block group generally contains between 200 and 1,000 households, and is delineated to never cross boundaries of states, counties, or census tracts, and therefore, in our analysis, serves as a proxy for "neighborhood." To be usable, each block group had to contain at least one PV home and one non-PV home. The estimated coefficients for this group of variables capture the combined effects of school districts, tax rates, crime, distance to central business district and other block group specific characteristics (Hoen, Wiser, Cappers, & Thayer, 2011).

Following a similar approach, a map of 2010 Census Block Groups was overlaid on the final set of homes, and the data set was trimmed such that only homes in a block group with both an EarthCraft certified home and comparable reference home were included, Figure 13.

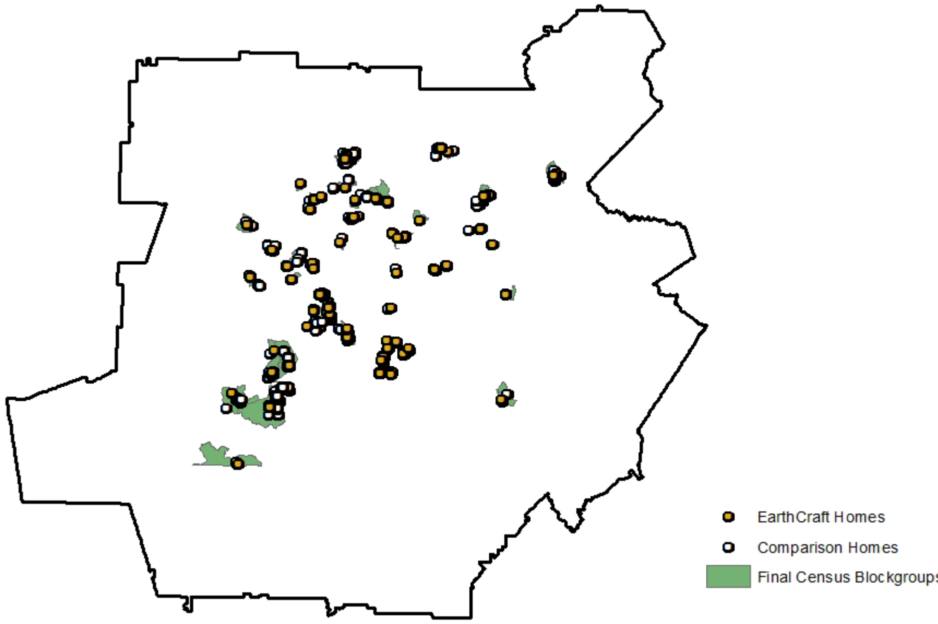


Figure 13 – Final data set with census block groups

This step resulted in a final data set of 1,094 homes, 300 of which were EarthCraft certified.

Statistical Analysis

Test Statistics

Before undertaking the final determination of a hedonic pricing model, several test statistics procedures were performed in order to understand the relationship between EarthCraft certified homes and the comparable homes in the given data set. The average sales price for EarthCraft certified homes was more than $50,000 higher than that of comparison reference homes, Table 4, with a distribution of sales prices higher than that of comparable homes, Figure 14. Test statistics provide additional weight to the validity of these findings.

Table 4 – Summary statistics final data set

	Comparison Homes	EarthCraft Certified Homes
Number	794	300
Average Sales Price	$ 375,098	$ 429,873
Average SP/SF	$ 120.81	$ 138.38
Average LP/SP	0.94	0.95

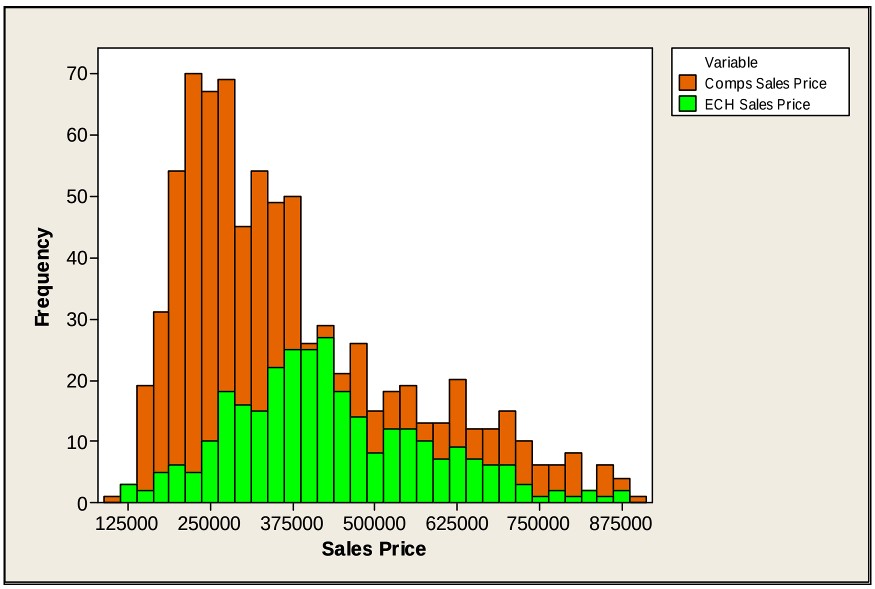


Figure 14 – Histogram of sales prices

First, a two sample t-test was conducted to determine whether the two samples, EarthCraft certified and comparison reference homes, are significantly different. This test evaluates the null hypothesis that the means of both sets are equal. The result of this test, a p-value of 0.0, disproves the null hypothesis showing that the sample means are significantly different, Figure 15.

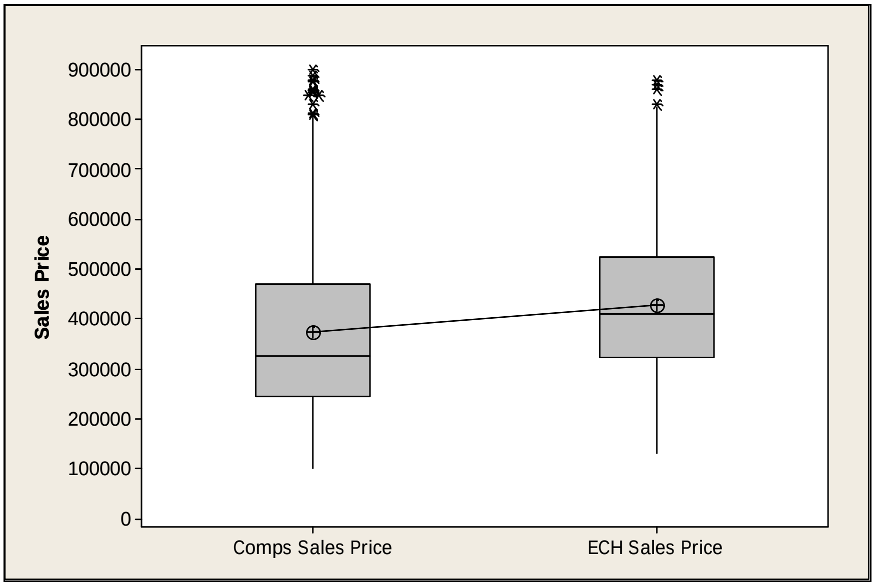


Figure 15 – Boxplot of sales price

Evaluating the distribution of sales price in Figure 14, it does not appear that sales price is normally distributed. Testing for normality using the Anderson-Darling normality test confirms this impression, as the resulting p-value disproves the null hypothesis that sales price is normally distributed, Figure 16.

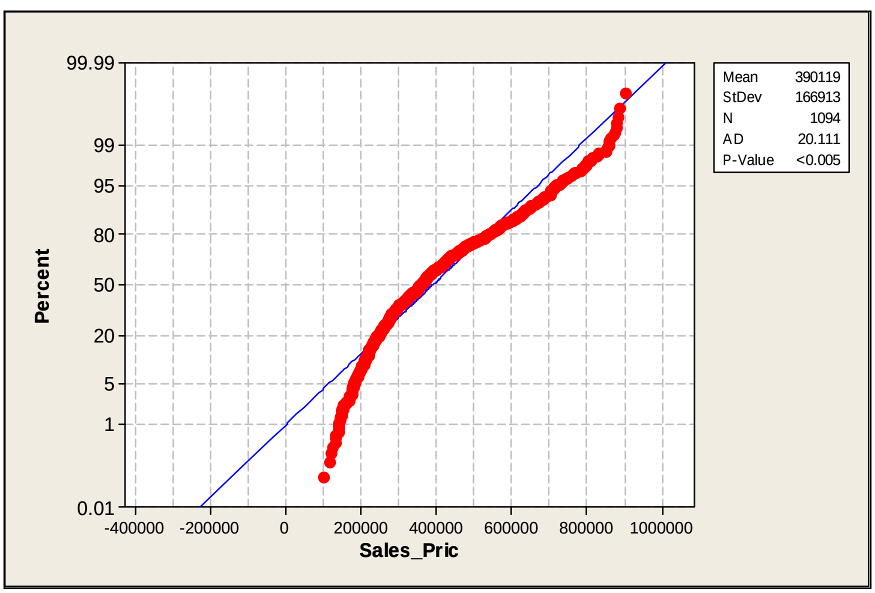


Figure 16 – Probability plot of sales price

Given the lack of a normal distribution for sales price, non-parametric test statistics were performed to further validate that EarthCraft homes have a higher average sales price than comparable reference homes. As both sample sets show a slight skew towards lower sales prices, a series of Mann-Whitney two sample rank tests was used to compare the median sales price values from both samples, testing the null hypotheses that the median sales prices for both tests are equal and that the median sales price for EarthCraft homes is less than that of comparable reference homes. The null hypotheses were disproved in both cases, providing statistical significance for the finding that EarthCraft homes have a higher median sales price than comparable reference homes.

Hedonic Regression Model

An iterative approach was taken in the determination of a hedonic sales price model for the sample data in question, evaluating the explanatory power of each potential independent variable and then its impact on the results of the overall hedonic model. From the literature review, all studies exploring the sales premium associated with green labels and individual features included four classes of explanatory variables:

1. Green certification or the presence of green features for the property in each real estate transaction
2. Location of real estate transaction
3. Time of real estate transaction
4. Hedonic characteristics for the property in each real estate transaction

Thus, the hedonic model for this study is expected to include these explanatory variables as follows:

$$\ln(P_{ikt}) = \alpha + \beta_1 ECH_i + \beta_2 BG_k + \beta_3 T_t + \sum_n \beta_4 X_i + \varepsilon_{ikt}$$

where P_{ikt} is the home sales price for transaction i in in census block group k during time period t, ECH_i is a dummy variable for EarthCraft House certification, BG_k is the census block group where transaction i took place, T_t is the time period in which transaction i took place, and X_i is a vector of hedonic characteristics for the home in transaction i. As explanatory variables for green certification and location have already been determined, EarthCraft House certification and census block group, determining explanatory variables for time and hedonic characteristics remained.

The time of each home sales transaction, as determined by the closing date, can be broken down into multiple different time segments. Year, month, and quarter of sale were considered using linear regression analysis with each considered as the explanatory variable and natural log sales price as the dependent variable, as shown in Table 5.

Table 5 – Linear regression results, time explanatory variables

Variable	Adjusted R-Squared	P-Value
Year	4.7%	0.0
Quarter	5.4%	0.0
Month	5.5%	0.0

All three approaches showed statistical significance, but month was chosen to account for time period of sale given that it provided the largest explanation for natural log sales price.

A similar approach was taken to address the vector of hedonic characteristics for each home. The attribute data for each home outlined in Tables 1, 2, and 3 was considered individually using regression analysis. For categorical data, multiple regression was used with dummy variables, an example of which is shown in Table 6 with a partial data set for Façade Description shortened for clarity.

Table 6 – Example of dummy variables for categorical data

Façade	Stucco	Vinyl	Hardie
Brick	0	0	0
Stucco	1	0	0
Vinyl	0	1	0
Hardie	0	0	1

In the case of categorical variables with large explanatory power, further analysis considered each individual dummy variable within a category using this same linear regression approach. The top ten explanatory variables are listed in Table 7. A complete table showing these results can be found in the appendix.

Table 7 – Top ten explanatory variables

Variable	Coefficient	Adjusted R-Squared	Correlation	P-Value
Baths	0.323	41.9%	0.647	0.0
Square Footage	0.000287	35.1%	0.593	0.0
Slab on Grade	-0.458	28.3%	-0.532	0.0
3 Car Garage	0.469	22.0%	0.47	0.0
Stubbed Basement	0.341	15.5%	0.395	0.0
2 Car Garage	-0.366	15.3%	-0.392	0.0

Table 7 (continued)

Variable	Coefficient	Adjusted R-Squared	Correlation	P-Value
12 Place Dining Room	0.404	14.7%	0.385	0.0
Bedrooms	0.184	13.1%		0.0
Brick Four Sides	0.503	12.7%	0.358	0.0
Deck	0.29	11.5%	0.341	0.0

All ten variables are statistically significant, with p-values of 0.0, and the resulting coefficients align with expectations of these characteristic's impact on home sales prices, except in the case of a two car garage. Variables related to utility and home size – number of bathrooms, number of bedrooms, and square footage – would be expected to increase home sales price as shown. Those variables related to the finishes and features – three car garage, 12 place setting dining room, a four sided brick façade, and the inclusion of a deck – are associated with high end homes, making their explanatory power for sales price and positive coefficient fit with expectations. The two variables for home foundation – slab on grade and stubbed basement – also fit the expected outcome. Slab on grade homes tend to be on the entry level side of the market, and a stubbed basement adds value, as a homebuyer has the opportunity to finish the basement in the future.

Following this exercise, the hedonic model began to take shape. Individual explanatory variables were added to the model one at a time, beginning with the explanatory variables for location, sale period, and EarthCraft House certification. A hedonic model with these three variables explains 58.9% of the variation in home sales prices for the sample data.

Table 8 shows the cumulative results of this approach, showing the resulting cumulative adjusted R-Squared value for each added variable.

Table 8 – Explanatory variables effect on hedonic model

Variable	Cumulative Adjusted R-Squared
Census Blockgroups	52.9%
Month of Sale	57.4%
EarthCraft	58.9%
Baths	74.5%
Square Footage	80.1%
Slab on Grade	82.7%
3 Car Garage	84.7%
Stubbed Basement	84.7%
2 Car Garage	84.8%
12 Place Dining Room	85%
Bedrooms	85%
Brick Four Sides	85.5%
Deck	85.5%

In order to determine the set of variables that would make up the hedonic characteristics vector, X_i, the variables explored in the previous exercise were added to the model, starting with variable with the largest explanatory power, number of bathrooms. This approach determined that not all variables with large explanatory power had a recognizable improvement on the model, with stubbed basement and number of bedrooms being determined to not be statistically significant when considered in conjunction with these other variables. After the addition of a dummy variable for a four sided brick façade, no further improvement to the model results was found, with a resulting adjusted r-squared of 85.5%.

It should be noted that the addition of the census, financial, and high school rank data to the original home attribute data provided from Atlanta FMLS was not necessary to determine this finalized model. As noted in the literature, location and time of sale are highly correlated with neighborhood quality and financial factors that affect home sales prices. While this additional information was not used in the final model, it does provide additional background on how these factors affect home sales price, and the findings may be useful to builders in that they provide additional context when choosing the location and included finishes of a home built for speculative sale.

Chapter 4: Results

The hedonic model developed through this study explains over 85% of the variation in home sales prices for the sample data. The final form of this model followed expectations:

$$\ln(P_{ikt}) = \alpha + \beta_1 ECH_i + \beta_2 BG_k + \beta_3 M_t + \sum_n \beta_4 X_i + \varepsilon_{ikt}$$

where P_{ikt} is the home sales price for transaction i in in census block group k during month t, ECH_i is a dummy variable for EarthCraft House certification, BG_k is a vector of dummy variables for the census block group where transaction i took place, M_t is a vector of dummy variables for the month in which transaction i took place, and X_i is a vector of hedonic characteristics for the home in transaction i. The explanatory variable coefficients, standard error coefficients, T-Values, and p-values can be found in the appendix.

Validating Model Results

In order to evaluate the validity of the final hedonic regression model produced by this study the following six steps were reviewed (Rosenheim):

1. **Coefficients have expected sign**

The explanatory variables included in the hedonic regression model have the expected sign given the anticipated impact of each of these factors on home sales price. The individual variable coefficients, Table 9, show that all of these variables have a positive impact on home sales price except for a slab on grade foundation, which was previously noted to be expected for entry level housing. Note that EarthCraft House certification has a positive value, demonstrating a price premium for certification.

Table 9 – Hedonic model variable coefficients

Variable	Coefficient
EarthCraft Certification	0.0798
Baths	0.0681
Square Footage	0.000150
Slab on Grade	-0.136
3 Car Garage	0.0269
2 Car Garage	0.0833
Large Dining Room	0.0457
Brick Four Sides	0.126

2. No redundancy among explanatory variables

If any explanatory variables are highly correlated, it can lead to multicollinearity which can cause overcounting bias and a model with unreliable results. Examining the correlation of explanatory variables,

Table 10, the only two variables with strong correlation are the presense of a two or three car garage. This strong correlation exists becuase if a home does not have a two car garage, it likely has a three car garage, as demonstrated in Figure 17. Thus both variables were judged to be appropriately included in the final model.

Table 10 – Correlation of explanatory variables

	ECH	Baths	Square Footage	Slab on Grade	3 Car Garage	2 Car Garage	12 Place Dining Room
ECH							
Baths	0.071						
Square Footage	0.011	0.71					
Slab on Grade	-0.045	-0.379	-0.34				
3 Car Garage	-0.039	0.528	0.536	-0.361			
2 Car Garage	0.042	-0.433	-0.432	0.336	-0.87		
Large Dining Room	0.046	0.353	0.351	-0.206	0.263	-0.22	
Brick Four Sides	-0.078	0.351	0.288	-0.198	0.269	-0.238	0.262

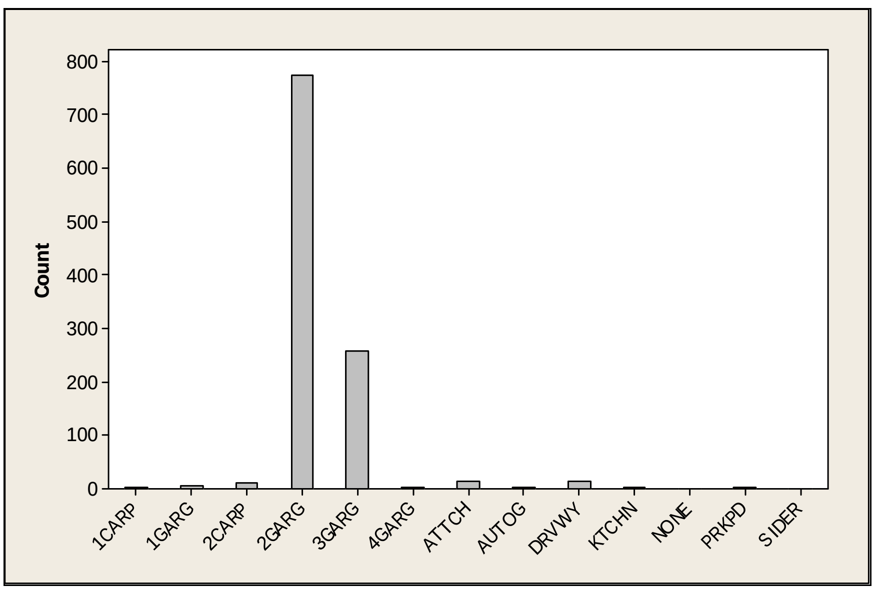


Figure 17 – Frequency of categorical variables, parking description

3. Coefficients statistically significant

Variables lacking statistical significance do not provide explanatory power to the model. Examining the p-values for each of the explanatory variables, Table 11, all show statistical significance, warranting their inclusion in the final model.

Table 11 – P-values for explanatory variables

Variable	P-Value
EarthCraft Certification	0.000
Baths	0.000
Square Footage	0.000
Slab on Grade	0.000
3 Car Garage	0.000
2 Car Garage	0.001
Large Dining Room	0.003
Brick Four Sides	0.000

4. Residuals normally distributed

A normal distribution with a mean of zero for the model residuals, the over and under predictions from the model, indicates that these residuals are randomly distributed and that the model does not have significant bias. Examining the historgram of standardized model residuals, Figure 18, the values approximate a normal distribution with a near zero mean. This finding means that the p-values associated with each explanatory variable can be trusted, the model is not missing any major explanatory variables, and that the relationship of each explanatory variable to sales price is likely linear in nature.

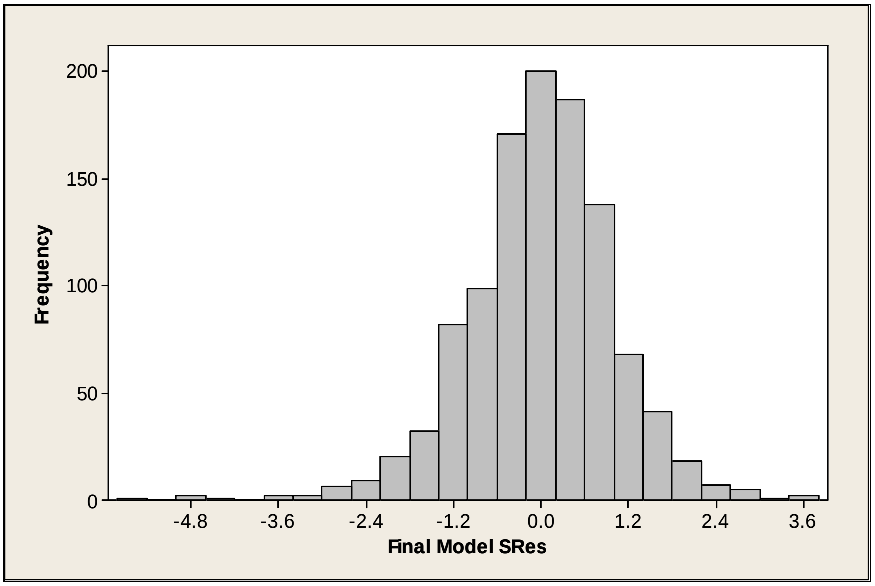


Figure 18 – Histogram of standardized residuals

5. **Strong adjusted r-squared**

Winth an adjusted r-squared value of 85.5%, the hedonic regression model that resulted from this analysis explains 85.5% of the variance in the natrual log of sales prices for the given sample data, an excellent sign for this model's ability to determine the impact of individual explanatory variables on sales price.

6. **Relationships do not vary significantly across the study area**

The use of census block groups as a location input for the model was meant to capture the effects of neighborhood quality and other location specific factors on the sales price of each home. Given that the inclusion of the additional information from the U.S. Census Data and high school rankings was not found to improve the model, it can be assumed that most of the location effect on sales price was captured through this approach; however, the ArcGIS software used in the data processing portion of the project has a tool that can determine if this is actually the case. The Spatial Autocorrelation (Morans I) tool in ArcGIS can test the value of attribute data associated with each home to determine if it exhibits spatial autocorrelation or clustering. The standardized residual associated with each home was input into this tool to ensure that the residuals followed a random distribution and the model was not under or over prediciting in any particular spatial area.

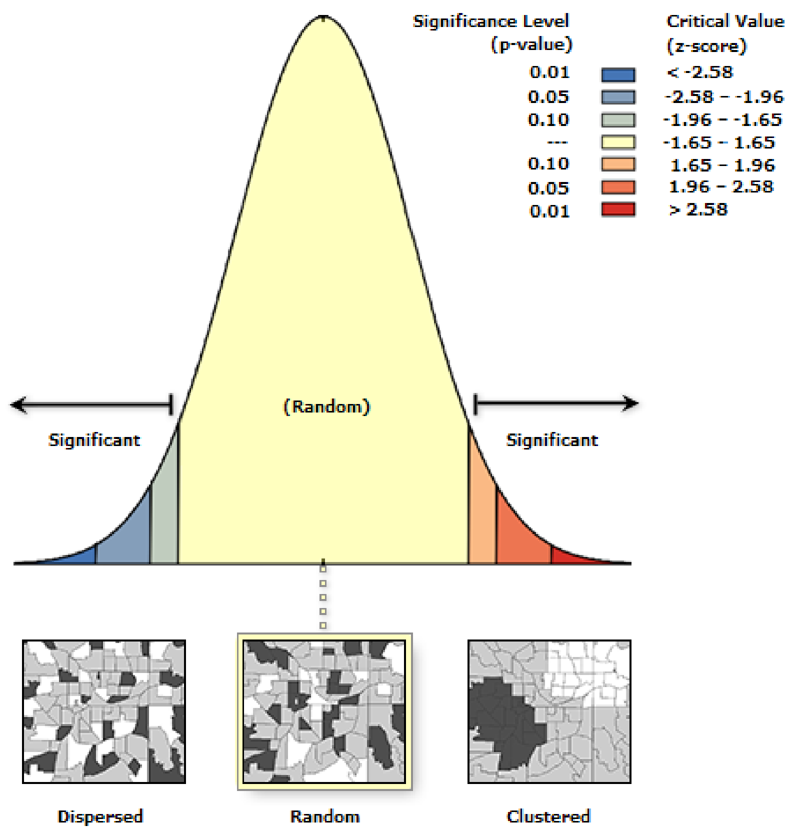


Figure 19 – Spatial autocorrelation (Morans I) analysis of standardized residuals

The results from the spatial autocorrelation tool, Figure 19, show that the standardized residuals from the model follow a random distribution, meaning that the use of census block groups as a location input for the model provides sufficient explanation of location effects on home sales price.

Determining the Price Premium of EarthCraft Certification

The natural log of sales price was chosen as the dependent variable for the hedonic regression model because it allow for the determination of the percent change that each explanatory variable has on the dependent variable. From a report documenting the methods to develop a home price index for homes in Philadelphia which used a similar logarithmic transformation, "Although the [logarithmic transformation of the regression specification] is still linear in its specification, it is nonlinear in its variables. Logarithmic transformations have the unique property of converting a relationship from levels to percents" (Gillen, 2005) . Whereas the estimated coefficients for a model where sales price was the dependent variable would show the change in dollar terms of a home's sales price associated with each explanatory variable, the estimated coefficients from a logarithmic transformation show the percent change in a home's sales price associated with each explanatory variable. Thus the estimated coefficient for EarthCraft House, β_1, expresses the percent change in home sales price as follows:

$$\beta_1 = \frac{\%\Delta P_{itk}}{\Delta ECH_i}$$

The percent change in sales price associated with EarthCraft House certification can then be determined by taking the exponential of the estimated coefficient and then subtracting one:

$$\%\Delta P_{itk} = e^{\beta_1} - 1$$

Taking the estimated coefficient for EarthCraft House certification, 0.0798, the impact of EarthCraft House certification home sales price is an increase of 8.3%, a significant price premium. Completing the same operation on the estimated coefficient for the other explanatory variables demonstrates the impact of each explanatory variable on sales price, Table 12, quantifying the effects examined in step one of the previous section.

Table 12 – Impact of explanatory variables on sales price

Variable	Coefficient	% Impact
EarthCraft Certification	0.0798	8.31%
Baths	0.0681	7.05%
Square Footage	0.00015	0.02%
Slab on Grade	-0.136	-12.72%
3 Car Garage	0.0269	2.73%
2 Car Garage	0.0833	8.69%
Large Dining Room	0.0457	4.68%
Brick Four Sides	0.126	13.43%

Chapter 5: Conclusions and Recommendations

The hedonic regression pricing model developed through this research showed a significant increase in home sales price associated with green building certification and explains 85.5% of the variability in observed sales prices for the sample set of Atlanta home sales. Homes that earned certification under the local EarthCraft House green building program demonstrated a sales price premium of 8.3%, which equates to a dollar value of over $28,000 when considering the average home sales price for the entire metropolitan Atlanta region of $335,914. The model also showed a significant impact on home sales price for location, time of sale, and certain individual housing characteristics in addition to EarthCraft House certification, demonstrating that housing value is a sum of the effects from these different factors. Location was determined to have the largest explanatory power, explaining over half of the variance in sales price for the observed data. Time of sale was found to be a sufficient explanatory variable to account for those time dependent factors that affect home sales price. Those features associated with both entry level and premium housing products were found to have the expected impact on home sales price, with size factors, the presence of a garage, and exterior and interior finishes found to have a large influence on home sales price. The findings of this research have practical applications for professionals in the construction and real estate industry, as well as potential homebuyers of green certified housing.

Builders and developers can use the sales premium identified by this study to build a business case for participation in green building programs. If the sales premium associated with certification exceeds the added cost and effort required, participation in these programs would result in a profit for developers of green certified housing. Given that well planned green building projects have little added cost and total home sales price is a function of financing costs, land costs, and builder profit in addition to construction costs, the added value of green building certification would likely yield a positive return on investment. More research is needed addressing the added cost of green building certification for individual projects, in order to further make the business case for participation in these programs.

Demonstrating a significant premium for green certified housing is also a first step in making the case to both real estate appraisers and financial institutions that green building certification should be recognized as a feature that increases the value of certified properties, as there is not currently a formalized approach in the industry to assessing the added value associated with green building certifications and the features incorporated into homes in order to earn these labels. The data gathered to perform this study revealed that there is a need for greater understanding of green building in the real estate community, and this research and the findings from similar studies should serve as the basis of outreach efforts to real estate professionals in order to provide education on the benefits and market recognition of these programs.

In the same way that builders and developers must make a business case for participating in green building programs through increased sales prices, potential homebuyers must recognize reduced operating and ownership costs for green certified homes to justify a higher purchase price. EarthCraft House and most other green building programs require projects to meet certain energy savings requirements, but these savings are typically based on projections of energy consumption from energy modeling programs and not predictions of actual energy use. Further research is needed to validate the energy savings for green building programs and to quantify the added value of other outcomes associated with these programs, including claims of increased durability and healthier indoor environments.

This research also provides value to green building program administrators and other professionals in the sustainability movement, validating the market recognition of their efforts in developing and promoting these programs. The approach put forward in this study could have further application in evaluating other green building labels in the Atlanta metropolitan area, as well as the value of EarthCraft house in other geographic regions. Since the EarthCraft House program was developed in the Atlanta area and has been active since 1999, it can be assumed that EarthCraft House has high recognition in the Atlanta market. Determining if other green building labels demonstrated a similar sales price premium in the Atlanta real estate market and if the price premium observed for EarthCraft House was echoed in other market areas where the program has taken hold would provide additional benefits to the findings of this study. Given the variety of different green building programs, this recommendation for additional research would provide builders and developers with information on how they could best respond to the consumer demand present in the local real estate market.

Appendices

Residential Green and Energy Efficiency Addendum

AI Reports® Form 820.03*	Client File #:	Appraisal File #:	
	Residential Green and Energy Efficient Addendum		
	Client:		
	Subject Property:		
	City:	State:	Zip:

Additional resources to aid in the valuation of green properties and the completion of this form can be found at http://www.appraisalinstitute.org/education/green_energy_addendum.aspx

ENERGY EFFICIENT ITEMS

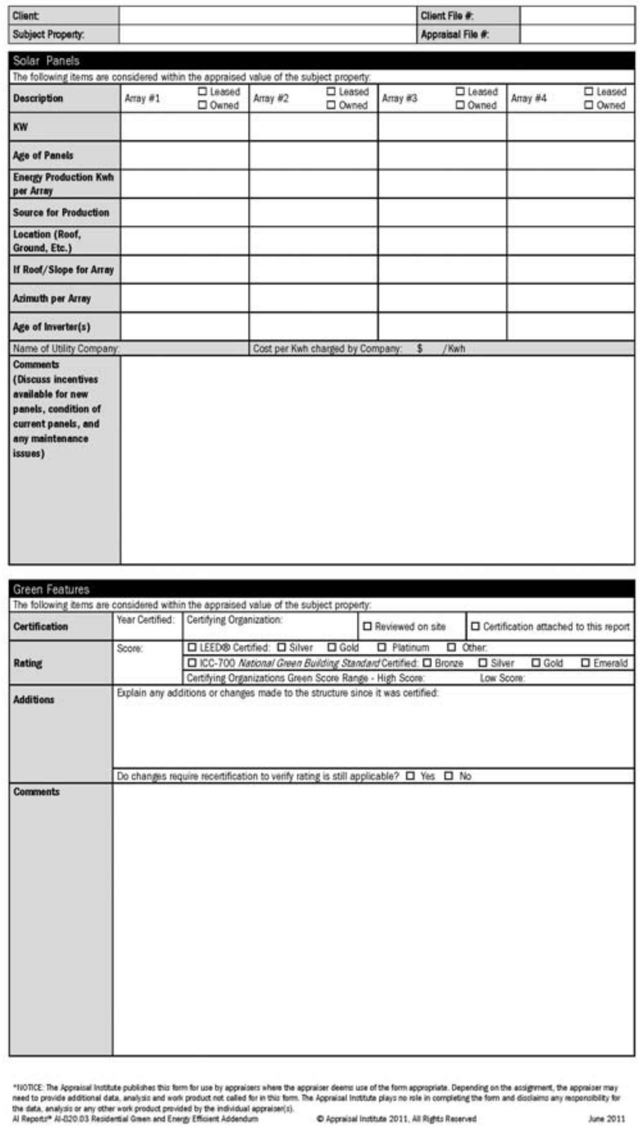
The following items are considered within the appraised value of the subject property:

Insulation	☐ Fiberglass Blown-In ☐ Foam Insulation ☐ Cellulose ☐ Fiberglass Batt Insulation ☐ Other (Describe): ☐ Basement Insulation (Describe): ☐ Floor Insulation (Describe):	R-Value: ☐ Walls ☐ Ceiling ☐ Floor
Water Efficiency	☐ Reclaimed Water System (Explain): ☐ Rain Barrels - #: ☐ Cistern - Size: Gallons ☐ Rain Barrels Provide Irrigation	Location:
Windows	☐ ENERGY STAR® ☐ Low E ☐ High Impact ☐ Storm ☐ Double Pane ☐ Triple Pane ☐ Tinted ☐ Solar Shades	
Day Lighting	☐ Skylights – #: ☐ Solar Tubes - #: ☐ ENERGY STAR Light Fixtures ☐ Other (Explain):	
Appliances	ENERGY STAR Appliances: ☐ Range/Top ☐ Dishwasher ☐ Refrigerator ☐ Other: Water Heater: ☐ Solar ☐ Tankless (On Demand) Size: Gal.	Appliance Energy Source: ☐ Propane ☐ Electric ☐ Natural Gas ☐ Other (Describe):
HVAC (Describe in Comments Area)	☐ High Efficiency HVAC – SEER: ☐ Heat Pump ☐ Thermostat/Controllers ☐ Passive Solar ☐ Programmable Thermostat ☐ Wind ☐ Radiant Floor Heat ☐ Geothermal	
Energy Rating	☐ ENERGY STAR Home ☐ HPwES (Home Performance with ENERGY STAR) ☐ Other (Describe):	☐ Indoor Air PLUS Package ☐ Energy Recovery Ventilator Unit ☐ Certification Attached
HERS Information	Rating: Date Rated: Monthly Energy Savings on Rating: $	
Utility Costs	Average Utility Cost: $ per month based on:	☐ Dashboards - #:
Energy Audit	Has an energy audit/rating been performed on the subject property? ☐ Yes ☐ No ☐ Unknown If yes, comment on work completed as result of audit.	
Comments		

*NOTICE: The Appraisal Institute publishes this form for use by appraisers where the appraiser deems use of the form appropriate. Depending on the assignment, the appraiser may need to provide additional data, analysis and work product not called for in this form. The Appraisal Institute plays no role in completing the form and disclaims any responsibility for the data, analysis or any other work product provided by the individual appraiser(s).

AI Reports® AI-820.03 Residential Green and Energy Efficient Addendum June 2011

Figure 20 – Residential Green and Energy Efficiency Addendum, Page 1



Client:		**Client File #:**	
Subject Property:		**Appraisal File #:**	

Solar Panels

The following items are considered within the appraised value of the subject property:

Description	Array #1 ☐ Leased ☐ Owned	Array #2 ☐ Leased ☐ Owned	Array #3 ☐ Leased ☐ Owned	Array #4 ☐ Leased ☐ Owned
KW				
Age of Panels				
Energy Production Kwh per Array				
Source for Production				
Location (Roof, Ground, Etc.)				
If Roof/Slope for Array				
Azimuth per Array				
Age of Inverter(s)				
Name of Utility Company:		Cost per Kwh charged by Company: $ /Kwh		
Comments (Discuss incentives available for new panels, condition of current panels, and any maintenance issues)				

Green Features

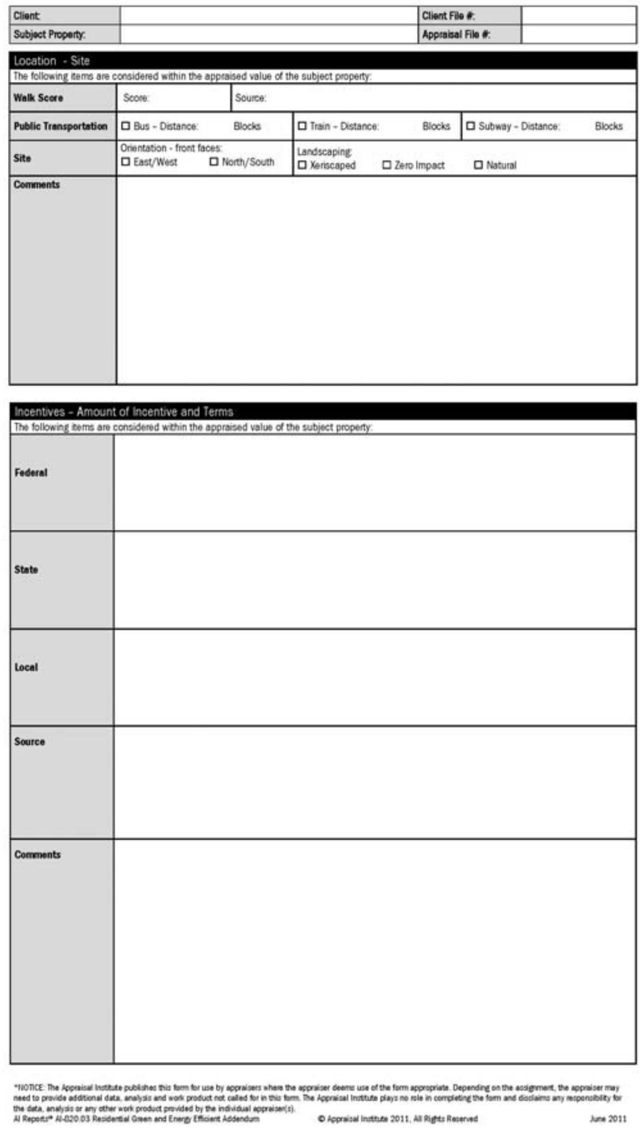
The following items are considered within the appraised value of the subject property:

Certification	Year Certified:	Certifying Organization:	☐ Reviewed on site	☐ Certification attached to this report
Rating	Score:	☐ LEED® Certified: ☐ Silver ☐ Gold ☐ Platinum ☐ Other:		
		☐ ICC-700 *National Green Building Standard* Certified: ☐ Bronze ☐ Silver ☐ Gold ☐ Emerald		
		Certifying Organizations Green Score Range - High Score: Low Score:		
Additions	Explain any additions or changes made to the structure since it was certified:			
	Do changes require recertification to verify rating is still applicable? ☐ Yes ☐ No			
Comments				

*NOTICE: The Appraisal Institute publishes this form for use by appraisers where the appraiser deems use of the form appropriate. Depending on the assignment, the appraiser may need to provide additional data, analysis and work product not called for in this form. The Appraisal Institute plays no role in completing the form and disclaims any responsibility for the data, analysis or any other work product provided by the individual appraiser(s).

AI Reports® AI-020.03 Residential Green and Energy Efficient Addendum June 2011

Figure 21 – Residential Green and Energy Efficiency Addendum, Page 2



Client:		**Client File #:**	
Subject Property:		**Appraisal File #:**	

Location - Site

The following items are considered within the appraised value of the subject property:

Walk Score	Score:	Source:	
Public Transportation	☐ Bus – Distance: Blocks	☐ Train – Distance: Blocks	☐ Subway – Distance: Blocks
Site	Orientation - front faces: ☐ East/West ☐ North/South	Landscaping: ☐ Xeriscaped ☐ Zero Impact ☐ Natural	
Comments			

Incentives – Amount of Incentive and Terms

The following items are considered within the appraised value of the subject property:

Federal	
State	
Local	
Source	
Comments	

*NOTICE: The Appraisal Institute publishes this form for use by appraisers where the appraiser deems use of the form appropriate. Depending on the assignment, the appraiser may need to provide additional data, analysis and work product not called for in this form. The Appraisal Institute plays no role in completing the form and disclaims any responsibility for the data, analysis or any other work product provided by the individual appraiser(s).

AI Reports® AI-020.03 Residential Green and Energy Efficient Addendum June 2011

Figure 22 – Residential Green and Energy Efficiency Addendum, Page 3

Regression Analysis to Determine Hedonic Characteristics

Table 13 – Linear regression analysis of potential explanatory variables

Variable	Coefficient	Adjusted R-Squared	P-Value
Baths	0.323	41.9%	0.00
Square Footage	0.000287	35.1%	0.00
Basement Description	-	29.4%	0.00
Basement Description: Slab on Grade	-0.458	28.3%	0.00
Façade	-	28.1%	0.00
Interior	-	23.7%	0.00
Parking De	-	23.3%	0.00
Parking Description: 3 Car Garage	0.469	22.0%	0.00
Dining Room	-	19.0%	0.00
Basement Description: Bath Stubbed	0.341	15.5%	0.00
Parking Description: 2 Car Garage	-0.366	15.3%	0.00
Dining Room Description:12 Place Settings	0.404	14.7%	0.00
Exterior	-	14.7%	0.00
Bedrooms	0.184	13.1%	0.00
Façade Description: Brick 4 Sides	0.503	12.7%	0.00
Exterior Description: Deck	0.29	11.5%	0.00
% American Indian	-112.518	11.4%	-
Median Household Income	0.00000565	11.1%	0.00
Minority	-0.30749	8.1%	0.00
% Black	-0.31053	8.1%	-

Table 13 (continued)

Variable	Coefficient	Adjusted R-Squared	P-Value
Interior Description: 10' Ceiling Main	0.323	8.0%	0.00
Bath Description	-	7.9%	0.00
Unemployment	-0.033068	7.3%	0.00
Stories	0.259	7.1%	0.00
Year Built	-	6.4%	0.00
Master Bath Description	-	6.3%	0.00
Housing Units Percent Change 00-09	-0.12086	6.2%	0.00
Façade Description: Brick Front	-0.317	5.9%	0.00
Interior Description: 9' Ceiling Up	0.252	5.9%	0.00
Kitchen Description	-	5.9%	0.00
Façade Description: Brick 3 Sides	0.269	5.8%	0.00
Interior Description: 9' Ceiling	-0.218	5.8%	0.00
Interior Description:2 Story Foyer	-0.282	5.6%	0.00
One Race	-0.25795	4.9%	0.00
Façade Description: Concrete	-0.233	4.8%	0.00
Dining Room Description: Living/Dining	-0.406	4.7%	0.00
Exterior Description: Other	-0.355	4.6%	0.00
Neighborhood Amenities Description	-	4.4%	0.00
Lot Description	-	4.4%	0.00

Table 13 (continued)

Variable	Coefficient	Adjusted R-Squared	P-Value
Bedroom Description	-	4.1%	0.00
Poverty Rate	-0.009606	4.0%	0.00
Single Family Change 00-09	-0.00006312	4.0%	0.00
Multifamily Change 00-09	-0.00006312	4.0%	0.00
Atlanta Unemployment	-0.0335	3.8%	0.00
Basement Description: Bath	0.331	3.4%	0.00
High School Rank	-0.000759	3.3%	0.00
Lot Size	-	3.2%	0.00
Mean Commute Time	-0.01565	3.1%	0.00
Mobile Home Change 00-09	0.00016242	3.1%	0.00
Exterior Description: Landscaping	-0.286	2.9%	0.00
Federal Funds Effective Rate	0.0323	2.6%	0.00
Laundry Description	-	2.1%	0.00
Atlanta Housing Starts	0.000042	2.1%	0.00
% Two or More Races	-6.982	1.9%	-
Façade Description: Stone	-0.245	1.5%	0.00
Parking Description: Driveway	-0.417	1.5%	0.00
Dining Room Description: Separate	-0.108	1.4%	0.00
Façade Description: Cedar	0.291	1.2%	0.00
Dining Room Description: None	-0.401	1.2%	0.00

Table 13 (continued)

Variable	Coefficient	Adjusted R-Squared	P-Value
Exterior Description: Front Porch	-0.111	1.2%	0.00
% Native Hawaiian or Pacific Islander	231.3	1.2%	-
% Asian	1.3888	1.1%	-
Interior Description: Cathedral	-0.772	1.0%	0.00
Vacancy %	-1.103	1.0%	0.00
Y	0.231	0.9%	0.00
% White	0.1396	0.9%	0.002
Dining Room Description: Dining Area	-0.177	0.8%	0.00
Exterior Description: Fence	-0.131	0.7%	0.00
Sewer Description	-	0.7%	0.00
Interior Description: Double Vanity	-0.266	0.6%	0.01
Parking Description: 1 Car Garage	-0.441	0.6%	0.01
X	0.16	0.6%	0.01
Basement Description: Daylight	0.21	0.5%	0.01
Interior Description: 10' Ceiling Up	0.314	0.4%	0.03
Interior Description: Hardwood	-0.507	0.4%	0.02
Façade Description: Vinyl	-0.605	0.3%	0.04
Interior Description: Other	-0.713	0.2%	0.09
Parking Description: Attached	-0.217	0.2%	0.06

Table 13 (continued)

Variable	Coefficient	Adjusted R-Squared	P-Value
Tennis	-0.101	0.2%	0.06
Basement Description: Boat Door	0.268	0.1%	0.21
Façade Description: Framed	-0.125	0.1%	0.19
Interior Description: 9' Ceiling Low	0.111	0.1%	0.12
Dining Room Description: Butler	-0.518	0.1%	0.41
Pool Description	-	0.1%	0.14
% Hispanic/Latino	-0.3561	0.1%	0.151
Basement Description: Crawlspace	0.0684	0.0%	0.31
Basement Description: Exterior Entry	0.162	0.0%	0.35
Basement Description: Finished	-0.182	0.0%	0.39
Basement Description: Full	0.0107	0.0%	0.88
Basement Description: Interior Entry	0.218	0.0%	0.47
Basement Description: Partial	0.056	0.0%	0.90
Façade Description: Brick Front	-0.0334	0.0%	0.28
Façade Description: Other	0.0362	0.0%	0.69
Façade Description: Rough	0.343	0.0%	0.42

Table 13 (continued)

Variable	Coefficient	Adjusted R-Squared	P-Value
Façade Description: Shingle	-0.0176	0.0%	0.85
Façade Description: Stucco	-0.005	0.0%	0.99
Water Description	-	0.0%	0.59
CPI	-0.00228	0.0%	0.47

Final Hedonic Regression Model

Table 14 – Final hedonic regression model summary

Explanatory Variable	Coefficient	Standard Error Coefficient	T-Value	P-Value
Constant	11.7299	0.0631	185.79	0.0
ECH	0.07984	0.01342	5.95	0.0
Blockgroup_104002	0.82729	0.08145	10.16	0.0
Blockgroup_114054	0.66231	0.0469	14.12	0.0
Blockgroup_114111	0.4511	0.1009	4.47	0.0
Blockgroup_114121	0.64874	0.04221	15.37	0.0
Blockgroup_115032	0.57572	0.05373	10.71	0.0
Blockgroup_115033	0.52543	0.03772	13.93	0.0
Blockgroup_116181	0.4325	0.1203	3.59	0.0
Blockgroup_1303072	0.36665	0.04744	7.73	0.0
Blockgroup_1304041	0.30044	0.04428	6.79	0.0
Blockgroup_16042	0.30347	0.0319	9.51	0.0
Blockgroup_204001	1.07146	0.07824	13.69	0.0
Blockgroup_212101	0.5198	0.1193	4.36	0.0
Blockgroup_214052	0.81822	0.05807	14.09	0.0
Blockgroup_224012	1.3479	0.1229	10.97	0.0
Blockgroup_224032	0.9688	0.1002	9.67	0.0
Blockgroup_227003	1.0118	0.05603	18.06	0.0
Blockgroup_228003	0.85636	0.09945	8.61	0.0
Blockgroup_238012	0.53656	0.04715	11.38	0.0
Blockgroup_301013	0.22105	0.04451	4.97	0.0
Blockgroup_302181	0.315	0.03949	7.98	0.0
Blockgroup_302342	0.1425	0.05179	2.75	0.0
Blockgroup_303102	0.31698	0.07113	4.46	0.0
Blockgroup_303221	0.47732	0.06011	7.94	0.0
Blockgroup_303302	0.45557	0.05664	8.04	0.0
Blockgroup_303422	0.47606	0.06278	7.58	0.0
Blockgroup_306021	0.47369	0.04812	9.84	0.0
Blockgroup_307003	0.0215	0.1017	0.21	0.8
Blockgroup_308003	0.51694	0.07152	7.23	0.0
Blockgroup_309015	0.3891	0.08678	4.48	0.0
Blockgroup_31001	0.61164	0.0704	8.69	0.0
Blockgroup_311012	0.61764	0.07147	8.64	0.0
Blockgroup_311082	0.58697	0.05114	11.48	0.0

Table 14 (continued)

Explanatory Variable	Coefficient	Standard Error Coefficient	T-Value	P-Value
Blockgroup_311112	0.67147	0.087	7.72	0.0
Blockgroup_311123	0.52469	0.06157	8.52	0.0
Blockgroup_311182	0.5043	0.05939	8.49	0.0
Blockgroup_312063	0.54369	0.03815	14.25	0.0
Blockgroup_312091	0.6503	0.03616	17.98	0.0
Blockgroup_313131	0.55932	0.04868	11.49	0.0
Blockgroup_501081	0.34879	0.02892	12.06	0.0
Blockgroup_502141	0.34119	0.03971	8.59	0.0
Blockgroup_503112	0.56208	0.04654	12.08	0.0
Blockgroup_503134	0.30744	0.04666	6.59	0.0
Blockgroup_505301	0.35033	0.05663	6.19	0.0
Blockgroup_507181	0.35626	0.07786	4.58	0.0
Blockgroup_52003	0.78102	0.04797	16.28	0.0
Blockgroup_603043	0.01607	0.04221	0.38	0.7
Blockgroup_69002	0.47076	0.05054	9.31	0.0
Blockgroup_801021	0.00561	0.06593	0.09	0.9
Blockgroup_801022	0.17746	0.0372	4.77	0.0
Blockgroup_805111	-0.008	0.04006	-0.2	0.8
Blockgroup_806021	0.35805	0.02976	12.03	0.0
Blockgroup_87004	0.37415	0.03923	9.54	0.0
Blockgroup_88001	0.50257	0.0368	13.66	0.0
Blockgroup_908031	0.21273	0.02837	7.5	0.0
Blockgroup_909012	0.27904	0.03346	8.34	0.0
Blockgroup_909021	0.40306	0.05983	6.74	0.0
Blockgroup_909044	0.51899	0.04995	10.39	0.0
Blockgroup_910051	0.30827	0.05767	5.35	0.0
Blockgroup_910061	0.25625	0.06721	3.81	0.0
Month_2.00	0.02679	0.05083	0.53	0.6
Month_3.00	0.01032	0.05012	0.21	0.8
Month_4.00	-0.0151	0.05095	-0.3	0.8
Month_5.00	0.00187	0.04991	0.04	1.0
Month_6.00	-0.03955	0.04834	-0.82	0.4
Month_7.00	-0.01005	0.04856	-0.21	0.8
Month_8.00	-0.04632	0.05358	-0.86	0.4
Month_9.00	-0.04587	0.05654	-0.81	0.4
Month_10.00	-0.05676	0.05268	-1.08	0.3
Month_11.00	-0.07548	0.04849	-1.56	0.1

Table 14 (continued)

Explanatory Variable	Coefficient	Standard Error Coefficient	T-Value	P-Value
Month_12.00	-0.04043	0.05144	-0.79	0.4
Month_13.00	0.00443	0.05832	0.08	0.9
Month_14.00	-0.10259	0.05494	-1.87	0.1
Month_15.00	-0.08341	0.05139	-1.62	0.1
Month_16.00	-0.03408	0.05329	-0.64	0.5
Month_17.00	-0.07701	0.04934	-1.56	0.1
Month_18.00	-0.12031	0.04962	-2.42	0.0
Month_19.00	-0.10703	0.05254	-2.04	0.0
Month_20.00	-0.1698	0.05557	-3.06	0.0
Month_21.00	-0.08607	0.05919	-1.45	0.1
Month_22.00	-0.10363	0.07111	-1.46	0.1
Month_23.00	-0.27882	0.06746	-4.13	0.0
Month_24.00	-0.21721	0.05574	-3.9	0.0
Month_25.00	-0.28972	0.06622	-4.38	0.0
Month_26.00	-0.11272	0.05914	-1.91	0.1
Month_27.00	-0.16712	0.06209	-2.69	0.0
Month_28.00	-0.16231	0.06531	-2.49	0.0
Month_29.00	-0.22389	0.05672	-3.95	0.0
Month_30.00	-0.21945	0.05846	-3.75	0.0
Month_31.00	-0.25398	0.05349	-4.75	0.0
Month_32.00	-0.22927	0.06227	-3.68	0.0
Month_33.00	-0.4512	0.0605	-7.46	0.0
Month_34.00	-0.30704	0.05813	-5.28	0.0
Month_35.00	-0.21047	0.05883	-3.58	0.0
Month_36.00	-0.33134	0.05674	-5.84	0.0
Month_37.00	-0.29253	0.04676	-6.26	0.0
Month_41.00	-0.27061	0.06375	-4.24	0.0
Month_42.00	-0.22187	0.0542	-4.09	0.0
Month_43.00	-0.26731	0.06254	-4.27	0.0
Month_44.00	-0.27633	0.05553	-4.98	0.0
Month_45.00	-0.24638	0.06032	-4.08	0.0
Month_46.00	-0.25635	0.05543	-4.62	0.0
Month_47.00	-0.30862	0.06697	-4.61	0.0
Month_48.00	-0.26979	0.05059	-5.33	0.0
Baths	0.068052	0.009887	6.88	0.0
Square Footage	0.00015	0.00001033	14.55	0.0
Slab on Grade	-0.13633	0.01314	-10.37	0.0

Table 14 (continued)

Explanatory Variable	Coefficient	Standard Error Coefficient	T-Value	P-Value
3 Car Garage	0.26861	0.02975	9.03	0.0
2 Car Garage	0.08327	0.02473	3.37	0.0
Dining Room 12 PST	0.04573	0.01527	2.99	0.0
Brick 4 Sides	0.12567	0.0207	6.07	0.0

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