Housing Archetype Analysis for Home Energy-Efficient Retrofit in the Great Lakes Region

S.-K. Kim, T. Mrozowski, A. Harrell-Seyburn, N. Ehrlich, L. Hembroff, B. Lieburn, M. Mazor, A. McIntyre, C. Mutton, G. Parsons, M.G. Syal, and R. Wilkinson
Cost Effective Energy Retrofit (CEER)

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15013 Denver West Parkway

Golden, CO 80401

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Prepared by:

S.-K. Kim, T. Mrozowski, A. Harrell-Seyburn, N. Ehrlich, L. Hembroff,

B. Lieburn, M. Mazor, A. McIntyre, C. Mutton, G. Parsons, M.G. Syal, and R. Wilkinson

Cost Effective Energy Retrofit Team

200 Larkin Center, 1605 Joseph Drive

Midland, MI 48674

NREL Technical Monitor: Michael Gestwick

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The work presented in this report does not represent performance of any product relative to regulated minimum efficiency requirements.

The laboratory and/or field sites used for this work are not certified rating test facilities. The conditions and methods under which products were characterized for this work differ from standard rating conditions, as described.

Because the methods and conditions differ, the reported results are not comparable to rated product performance and should only be used to estimate performance under the measured conditions.

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Definitions

AHS	American Housing Survey
BA	Building America
BEopt™	Building Energy Optimization software
CEER Team	Cost Effective Energy Retrofit Team
DOE	U.S. Department of Energy
ft^2	Square feet
HVAC	Heating, ventilation, and air conditioning
MEB	Monthly energy bill
NREL	National Renewable Energy Laboratory
OSR	Office of Survey Research at Michigan State University

Executive Summary

This project report details activities and results of the "Housing Archetype Analysis for Home Energy-Efficient Retrofit in the Great Lakes Region" project undertaken by The Cost Effective Energy Retrofit (CEER) team targeted toward the U.S. Department of Energy goal of achieving 30%–50% reduction in existing building energy use. CEER consists of members from the Dow Chemical Company, School of Planning, Design, & Construction at Michigan State University, Ferris State University, and Habitat for Humanity Kent County.

The purpose of this project was to identify housing archetypes that are prevalent within the Great Lakes region and therefore offer significant potential for energy-efficient retrofit research and implementation due to the substantial number of homes possessing similar characteristics. Understanding the characteristics of housing groups referred to as "archetypes" by vintage, style, and construction characteristics can allow research teams to focus their retrofit research and develop prescriptive solutions for those structure types that are prevalent in a region or market with an end goal of accelerating adoption.

Key research activities included literature review, statistical analysis of national and regional data of the American Housing Survey (AHS) collected by the U.S. Census Bureau, analysis of Michigan-specific data, development of a housing taxonomy of architectural styles, case studies of two local markets (i.e., Ann Arbor and Grand Rapids in Michigan) and development of a suggested framework for characterizing local markets.

In order to gain a high level perspective, national and regional data from the U.S. Census Bureau were analyzed using cross tabulations, multiple regression models, and logistic regression to characterize the housing stock and determine prevalent house types using 21 variables. The data analysis identified 36 classification categories by date range, size and number of stories. Monthly energy cost data from the AHS were also correlated with housing characteristics. From this analysis housing sets with high potential for retrofit were identified based on prevalence and monthly energy bill.

Since energy retrofit is ultimately conducted at the local level, the CEER team examined census data for Michigan and other Great Lakes states as well as conducted local city case studies of Ann Arbor and Grand Rapids. This was done in order to understand how local markets may or may not match regional or national data. Available public information was viewed, input from housing experts was obtained, and market site visits were conducted. A housing taxonomy of architectural styles/features was developed and used to describe the local markets. Lastly, a framework was developed that can be useful to researchers or policy makers in determining high value housing archetypes for energy retrofit research, energy retrofit programs, or business market focus at a local level.

1 Problem Statement

1.1 Introduction

The Cost Effective Energy Retrofit (CEER) team, under funding from the Building America (BA) Program, undertook research to explore prevalent housing archetypes within the Great Lakes region that offer high potential for energy retrofit uptake based on numbers of similar houses and their characteristics. This project report outlines the research approach and results.

A primary research goal of the BA program is "to develop market-ready energy solutions that improve efficiency of new and existing homes in each U.S. climate zone" (U.S. Department of Energy 2012). Toward this goal CEER conducted this research, which is based on the premise that focusing technical research and energy retrofit programs on specific housing archetypes that occur in substantial numbers will help to improve adoption. Economies of scale for research and energy programs can be achieved from solving retrofit solutions for homes types that occur in high numbers.

The 2009 American Housing Survey (AHS) shows that nearly 90% of homes in the Midwest were built before energy codes were adopted and nearly 60% of all Midwest homes were constructed at a time when wall insulation was not commonly installed (prior to 1970). By profiling the housing stock and matching research and energy retrofit programs to individual characteristics of specific prevalent archetypes, a substantial number of homes can be addressed and impacted.

The specific purpose of this study was to identify housing archetypes within the Great Lakes region that are prevalent and therefore have high potential for energy-efficient retrofit implementation within the region due to their substantial number and similar characteristics. Determining groups of housing by vintage, style, and construction characteristics allows the research team to determine effective retrofit solutions that are matched to the existing housing stock available and concentrate on those archetypes that are prevalent.

The project reports on Midwest regional data and profiles two local markets. Also reported is a housing taxonomy and a framework developed by CEER, which can be implemented in local markets to help understand the housing characteristics and opportunities for research and programs that target high impact archetypes.

1.2 Background

Since the 1970s oil crisis, the government and homeowners have increasingly become aware of the need to conserve energy. According to energy data from 1980, the average home built in the 1960s consumed 65 kBtu/ft^2 of energy annually. In 1992; only five states and one U.S. territory had building codes that required energy efficiency. By 2008, every state except for 10 and one U.S. territory had energy-efficient building codes (U.S. Department of Energy 2008).

The 2009 AHS (U.S. Census Bureau 2009) shows there are 29,400,380 housing units in the Midwest region. Of this stock 68.66% or 20,108,792 units are in single-family detached homes. About 17.97% of Midwest housing was built before 1929, 13.52% from 1930–1949, 26.65% from 1950–1969, and 41.87% after 1970. The significant number of existing homes and age of

these homes constructed before the year 2000 provide substantial opportunity for energy savings through energy retrofit.

Age of home has important relevance to energy retrofit solutions. Common construction technologies can be matched to ranges of years built. For example in the Midwest, homes built before 1929 are largely "balloon" framed construction. Walls in these homes were rarely insulated. Platform framing became prevalent in the 1930s and is the prevalent form today. Sheet products such as plywood and gypsum panels became popular starting in the 1940s and 1950s (O'Brien 2010; Lstiburek 2010). Use of wall insulation was not standard until the mid-1970s. After the energy crisis in the 1970s, use of residential wall insulation became prevalent, and common use of improved window systems began to occur in the late 1970s and early 1980s. Improved heating, ventilation, and air conditioning (HVAC) systems in the 1980s, the introduction of energy codes in the late 1990s, and improved insulation materials and air sealing products all impacted housing constructed in the 1990s and after 2000. Window improvements, siding changes, and the introduction of air barriers are additional examples of changes in construction technology that can influence successful retrofit measures and can be matched to housing construction chronology.

Building form is also relevant to energy retrofit solutions. The 2009 AHS shows that 44% of all Midwest housing is constructed with basements (U.S. Census Bureau 2009). The vast majority of this housing with basements does not include basement insulation. Basement wall insulation has only recently started to become common (since 2005) in Midwest home construction.

Housing architectural style can also impact retrofit solutions. For instance, building shape, roof configuration, window distribution, siding material, ratio of wall surface area to floor square footage, and configuration all can influence energy performance. Certain home architectural styles, particularly pre-1930, may consist of multiple irregular forms rather than being concentrated in a single block form. Queen Anne style homes, for example, are multiform and include bay style projections and overhanging forms yielding increased wall surface area to floor area ratios as well as components that may be less accessible for insulating and air sealing. Retrofitting exteriors of these homes, particularly when located in historic districts, will often be limited by local regulations. It is common for local regulations in historic districts to limit window replacement configurations, siding material changes and roof replacements to maintain consistency with existing appearances.

Some home styles, particularly those built in the Midwest starting in the late 1970s, incorporated vaulted ceilings in dining, family, and living rooms through the use of scissors trusses or contact drywall installed on dimensional lumber or engineered lumber roof rafters, which influence options and solutions for adding roof insulation.

As a practical matter the ability to conduct energy modeling and simulations of complex building forms is limited. It is difficult to model complex roof shapes, complicated building forms, and vaulted ceilings in Building Energy Optimization software (BEopt™) or other simulation programs. Certain elements such as roof dormers are difficult to incorporate into a BEopt model, yet they influence energy consumption. For instance, modeling the form variations of a Queen Anne style or gothic revival home constructed in 1900 with any precision is difficult. The consequence is that energy modelers are likely to take shortcuts and abbreviations of forms and

window configurations in developing simulations. These shortcuts and abbreviations all are likely to influence the accuracy of results. Understanding which existing home types are prevalent and their architectural characteristics can be useful as new features are considered for inclusion in BEopt and prioritized for software development.

Effective energy-retrofit solutions should be optimized for housing characteristics such as style, construction type, materials, configuration, existing construction details, building form, and number of stories, since they all can influence retrofit solutions, access for insulation and air sealing and ability to run new ducts (Hendron and Engebrecht 2010). Furthermore, many of these characteristics are common to certain housing archetypes that frequently occur and can be grouped by vintage and building form, and occur in sufficient numbers within a region. Understanding the housing stock and prevalence of archetypes can help researchers to select case studies and concentrate whole building technical energy retrofit research on home types which are most common within a region.

1.2.1 Prior Research

There is a substantial amount of technical literature on energy retrofit. Some of the technical research indicates that understanding the housing stock is important. Sherman and McWilliams (2007) explored air leakage of U.S. homes and predicted normalized air leakage through the use of the Sherman–Wilson model in U.S. homes. The study highlighted the need to understand regional housing conditions before running any simulations for providing recommendations for home energy-efficient improvements.

Several BA case studies highlighted energy efficiency of individual components of a house (i.e., wall insulation, ceiling insulation, basement, windows and doors, air sealing, HVAC, lights, and appliances), but did not present well how they selected subject homes for simulations or experiments to measure the energy-efficient retrofit need. This lack of representativeness of subject homes for the experiments was also mentioned by Spanier et al. (2012).

One recent publication titled *Chicagoland Single-Family Housing Characteristics* identified 15 groups of existing homes located in Cook County, Illinois based on their architectural characteristics and measured these 15 groups' current energy efficiencies using BEopt (Spanier et al. 2012). The research also proposed future energy efficiency upgrading based on BEopt modeling results. Their research findings are expected to provide practical guidelines for various stakeholders, including homeowners in their region. Although their research was conducted in a different local market from the CEER research project, the findings strongly support the assumption that retrofit strategies should be established based on a close understanding of various housing types and characteristics in a local market.

To date, BA teams have conducted a number of case studies of existing homes in several regions and climate zones. These case studies can be grouped into several categories, including those addressing pre-1930s homes such as a Four Square home in Concord, Massachusetts, built in 1916, (Pettit 2010); those from 1930–1970 such as a 1930s home retrofitted in Pittsburg, Pennsylvania (NREL 2009a); and those originally built after 1970 such as the Wapato, Washington retrofit project (NREL 2009b).

Case studies are available at www1.eere.energy.gov/buildings/residential/ ba_guides_studies_cold.html. However, there is limited discussion of how case study homes were selected or how dominant the case studies homes are in the regional market.

1.3 Benefits and Cost Effectiveness

This research targeted the Great Lakes cold climate sub-region and was undertaken to identify housing archetypes that are prevalent in this region. Understanding the mix of housing stock within a region can help researchers to focus technical whole building research and select case studies that are important for the region based on how commonly the archetypes occur.

Economies of scale for research impact can be achieved from identifying retrofit solutions for homes that occur in high numbers. Effective retrofit solutions specific to the archetype can be identified through technical research and thus disseminated offering potential for improving uptake. This market characterization research helps to determine the important home sets for the Great Lakes region from national data, analyzes two local markets in detail, and provides a framework for others that can be used to characterize local markets.

2   Experiment

2.1   Research Methods Overview

This research employed both qualitative and quantitative approaches to characterizing the regional and local markets. Key research activities included literature review, statistical analysis of national and regional data of the AHS (collected by the U.S. Census Bureau), analysis of Michigan-specific data, development of a housing taxonomy of architectural styles, case studies of two local markets (Ann Arbor and Grand Rapids, Michigan), and development of a suggested framework for characterizing local markets.

In order to gain a high level perspective, national and regional data obtained from the census.gov and AHS were analyzed using cross tabulations, multiple regression models, and logistic regression to characterize the housing stock and determine prevalent house types using 21 variables. The data analysis identified 36 classification categories by date range, size, and number of stories. Data analysis of monthly energy bill (MEB) data from the data file by housing classification category and the influence of housing characteristic variables was conducted. From this analysis housing sets with high potential for retrofit based on prevalence and MEB were identified.

Since energy retrofit is ultimately conducted at the local level, CEER examined census data for Michigan and other Great Lakes states and conducted local city case studies of Ann Arbor and Grand Rapids in order to understand how local markets may or may not match regional or national data. Available public information was viewed, input from housing experts was obtained, and market site visits were conducted. A housing taxonomy of architectural styles and features was developed and used to describe the local markets. Lastly, a market characterization framework was developed during the Ann Arbor local market study and field evaluated during the Grand Rapids study. The framework can be useful to researchers and policy makers in other local markets.

2.2   Research Objectives

Since the purpose of this study was to identify prevalent housing archetypes for the region, the following research questions were developed to guide the research:

1. Which housing archetypes dominate by number and distribution, generally in the Great Lakes sub-area of the cold climate region, when considering vintage, style, and construction type?

2. When considering major cities in Michigan, which housing archetypes offer significant opportunity for deep energy retrofit implementation based on numbers of structures and housing characteristics?

3. Which housing archetypes will be effective to address with retrofit programs in these regions?

4. Which housing archetype will be effective to address in the test homes for task 7.1 titled, "Evaluation and Testing of Individual Air Sealing Retrofit Measures," which is conducted in Grand Rapids?

5. What is the general framework for identifying and determining prevalent archetypes needing energy-efficient retrofitting in the Great Lakes sub-regions?

2.3 Research Steps, Measurements, and Processes

Our research targeted the Great Lakes sub-regions. The Council of Great Lakes Governors (2012) defines this region as the states of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. The Provinces of Ontario and Québec are included in these regions. This research specifically focuses on Michigan as a representative state. Core research steps were interactive with one another and are detailed below:

2.3.1 Collect and Analyze Regional Data

In order to understand national and regional contexts, several activities were undertaken, including a literature review of energy retrofit and housing architectural style literature, an analysis of Midwest housing information from the 2009 AHS collected by the U.S. Census Bureau, and development of a library of architectural styles.

2.3.2 Literature Review

As an initial step, the research team conducted a literature review of existing energy retrofit research, including academic literature, BA research reports, and BA case studies.

2.3.3 Development of a Taxonomy of Architectural Styles of Michigan Houses

As a starting point for identification of prevalent archetypes, the CEER team created a taxonomy of housing styles in order to have a common language and common definitions for classification of structures based on architectural features beyond vintage, number of floors, and square foot area. Architectural literature and consultation with architectural historians and preservation officers were used to identify a national taxonomy, which was then culled for common examples found in Michigan.

Based on the data sources, the CEER team created a taxonomy showing general architectural styles of houses that can be found in any areas in the United States. The initial housing style taxonomy was created in early 2011 and revised between July and August of 2011 based on review of staff members from the Michigan State Historic Preservation Office. The revised taxonomy was reviewed a second time in September 2011 and housing styles were narrowed to those typical for Michigan houses. The housing taxonomy is presented in Section 3.2 of this report.

Key sources of literature included the classic field guide for architectural historians, *A Field Guide to American Houses* (McAlester and McAlester 1984), and Web-based archives offered by historic preservation departments of municipal governments such as housing style information provided by the City of West Chicago (www.westchicago.org) and the City of Cincinnati (www.cincinnati-oh.gov). Other sources used included a number of Web-based sites targeted to builders, realtors, and homeowners such as architecture.about.com, oldhouses.com, allbusiness.com, detroithomemag.com, antiquehome.org, ineedaninspector.com, and 45thparallelrealty.net.

2.3.4 Housing Data Analysis

The Michigan State University Office for Survey Research (OSR) conducted an analysis of national and regional data from the 2009 AHS data files using cross-tabulations, multiple regression models, and logistic regression to characterize the national and Midwest housing stock by categories including date range, size, and number of floors. The AHS is a statistical

survey funded by the U.S. Department of Housing and Urban Development and conducted by the U.S. Census Bureau. It is the largest regular national housing sample survey in the United States and contains information on the number and characteristics of U.S. housing units as well as the households that occupy those units (U.S. Census Bureau 2011). Since 1985, the survey data in both the national and metropolitan area samples are collected from the same homes each survey year; consequently, the AHS can track changes in these housing units over time (U.S. Census Bureau 2011).

Cross-tabulations were conducted to compare the housing distribution by region-based housing characteristics. Multivariate analyses—both multiple linear regression and logistic regression models—were developed to determine the key house characteristic factors that independently affect energy consumption costs. Analysis of MEB data from AHS by housing classification category and influence of housing characteristic variables were conducted. From this analysis housing sets with high potential for retrofit based on prevalence and MEB were identified. Details and results of the data analysis are reported in Section 3.1 of this report.

2.3.5 Development of the Ann Arbor, Michigan Case Study

Since energy retrofit is ultimately conducted at the local level, the CEER team examined census data for Michigan and other Great Lakes states and conducted local city case studies of Ann Arbor and Grand Rapids in order to understand how state and local markets may or may not match regional or national data.

Ann Arbor was selected as the first case study city. Available public information was viewed, input from housing experts was obtained, market site visits were conducted, and Zillow.com was reviewed. The housing taxonomy of architectural styles and features developed at the early stages of the research was used in describing the local market. Lastly, a market characterization framework that proposed a specific process to identify prevalent housing archetypes for determining energy-efficient retrofit targets was developed, which can be useful to researchers and policy makers in determining high value housing archetypes for energy retrofit research, energy retrofit programs, and business market focus. The framework was tested in the subsequent case study conducted of Grand Rapids in summer 2012.

2.3.6 Investigation of Historical and Social Background

The CEER team used published sources, including articles, maps, and city histories to construct a brief history of the city. Establishing a city history allowed the team to understand city boundaries, growth patterns by era for the city, and its structure of neighborhoods.

2.3.7 Meetings With Local Housing Experts

The OSR met with knowledgeable housing experts, including realtors and city officials, to identify public information and relevant neighborhoods and archetypes that would likely dominate.

2.3.8 Review of Public Information

The CEER team and OSR reviewed public information, including census documents and housing reports furnished by the City of Ann Arbor to establish age distribution of housing units and numbers by decade.

2.3.9 Site Visits of Neighborhoods

Drive through site visits were conducted of key neighborhoods identified from public information with well-defined archetype groups in order to observe the housing stock and correlate with the housing taxonomy.

2.3.10 Analysis of Real Estate Source (Zillow.com)

The website, www.zillow.com, is an online real estate search tool that can be used to search on city properties currently for sale, recently sold, and for rent. A variety of filters are available that allowed the CEER team to run a number of searches by decade constructed.

The CEER team used the Zillow tools to view details on individual homes for sale, for rent, or recently sold. For Ann Arbor in excess of 3,000 properties were listed, representing about 7% of the entire housing stock. The CEER team matched the distribution of housing stock by decade to the Census Bureau data and found there was a close match between the Zillow-filtered searches and census data.

A variety of data about each home are contained in each individual property file, including year built, price, square foot area, exterior and interior photos, and narrative descriptions of its features and improvements. Reviewing the photos of individual homes allowed for matching of individual homes to the housing taxonomy styles. Furthermore, it was possible to gain an understanding of the types of upgrades that sellers had made to their houses. The vast majority of improvements were cosmetic, or functional such as bathroom or kitchen remodeling. Only rarely were energy efficiency upgrades mentioned, and when they were, they typically mentioned air conditioning upgrades or furnace upgrades, and almost never general energy retrofit upgrades.

The CEER team found Zillow to be an effective way to quickly view a local market and understand its housing stock. Use of Zillow along with corroborating information from the census, local housing experts, public documents, and site visits was a relatively quick and effective way to understand a local housing stock. However, the CEER team also noted that the housing data from Zillow could not cover the entire housing stock in the region, although the data represent the current housing stock in the market effectively.

2.3.11 Identification of Prevalent Archetypes for the Local Housing Stock Estimation—Review and Analysis of Archival Documents

The CEER team utilized sources including the housing taxonomy, census data, public information, information from public officials, and Zillow-filtered searches to identify three prevalent home types for Ann Arbor, including 1950s–1960s era ranches and "old west side charmers," which include two archetypes from the late 1800s and early 1900s. The Ann Arbor study is addressed in Appendix D.

2.3.12 Development of a Local Market Characterization Framework

The CEER team developed a framework for quickly characterizing a local market for profiling local housing stock and determining prevalent archetypes based on the Ann Arbor case study. Determining high impact archetypes by distribution is useful to researchers, program planners, and energy retrofit contractors in channeling their efforts to these archetypes.

2.3.13 Field Test the Framework and Identify Prevalent Archetypes for Building America Energy Retrofit Research in Grand Rapids

The framework identified from the Ann Arbor case study was field tested in Grand Rapids where CEER's current technical test homes are located. The results of this case study helped to document that the two test homes (1950s ranches) being utilized in Grand Rapids are from a dominant home set. While the initial target was to specifically identify future home types for use as research homes, field testing the framework allowed the CEER team to develop observations about its use.

Once prevalent housing archetypes in a local market and their taxonomies were identified, the team determined target archetypes for future energy retrofit research in Grand Rapids.

2.3.14 Revise and Document the Final Framework for Characterizing a Local Market for Energy Retrofit

The CEER team made revisions to the original framework and increased its emphasis on use of Zillow along with census data for quickly assessing a market. The CEER team believes the final framework for determining the dominant housing type should be useful for researchers and municipalities when they make a retrofit plan for the local housing's energy-efficient upgrade.

2.3.15 Final Reporting

The CEER team developed and submitted a final report that outlined activities, data, analysis, and results. The final report will contribute to establishing energy-efficient retrofit strategies for the local housing market.

3 Results

3.1 Housing Data Analysis: 2009 American Housing Survey

This section reports the analysis of data on the current national and regional housing stock. The major data source was the AHS (U.S. Census Bureau 2009). Data were analyzed by using statistical methods including cross-tabulation, multiple regression, and logistic regression to examine housing types and features impacting energy consumption. Common patterns in the houses in the Midwest were examined.[1]

The AHS is explicitly intended to collect data on a large sample of individual housing units so that a profile of the U.S. housing stock can be produced. It gathers a wide variety of information about the features of each housing unit, including year built, square footage, number of levels, attached garage or not, basement or not, number of bedrooms, number of bathrooms, separate dining area, fireplace or not, type of heating system, type of air conditioning system or not, the number of residents, the number of whom are children, and energy costs for electricity, gas, oil, and water. In addition, the energy expenditures for each type can be calculated and the major housing types that account for greater segments of the housing stock and higher energy expenditure can be determined.

3.1.1 About the Sample

A dataset file named NEWHOUSE was created from the 2009 AHS data for this study. There are actually two AHSs that are designed for different purposes: One is conducted nationwide and the other is conducted in metropolitan areas. None of the cities that were initially planned as test cities for this BA project were included in these metropolitan surveys. So our attention was focused on the most recently conducted national survey available and analyzed housing profiles mainly in the Midwest region.

By dividing the United States into areas consisting of counties or groups of counties and independent cities known as primary sampling units, the Census Bureau selects a sample of these units and then picks a systematic sample of housing units within the primary sampling units. For the 2009 American Housing Survey – National sample, about 82,000 housing units were originally selected and surveyed between April and September 2009 by means of phone interview or personal visit. Excluding ineligible units and non-interviews, 73,222 eligible sample units were consequently interviewed for the national data.

The file NEWHOUSE for this study contains household-level information, data recodes, unit characteristics, and weighting information. The data were obtained from www.huduser.org/portal/datasets/ahs/ahsdata09.html (U.S. Census Bureau 2009). The CEER team converted the current SAS format into SPSS format for our purpose of data mining and analysis.

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[1] 2009 AHS defined Midwest region as follows: *Midwest.* Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, North Dakota, and South Dakota.
Source: U.S. Census Bureau (2009). American Housing Survey 2009. Appendix- Definitions, Page A-26 Appendix A. Retrieved March 15, 2012 from www.census.gov/housing/ahs/files/Appendix%20A.pdf.

Caseweights in the file are expansion weights; i.e., they correct for unequal probabilities of selection and differential rates of non-response, while also projecting the weighted size of the sample up to the size of the actual total population.

3.1.2 Analysis and Results

3.1.2.1 General Characteristics of Housing Stock—Cross-Tabulations

In order to classify houses into types that could be related to energy consumption, the CEER team identified three criteria based on historical factors and physical features of houses: the year the house was built, number of stories in the house, and the size (square footage). The CEER team recoded these variables into new formats suitable for this study. The new variable "Year unit was built" has four categories: built before or in 1929, Built between 1930 and 1949, built between 1950 and 1969, and built after 1970; the new variable "Stories" has three categories: one story, two stories, and three or more stories; the size of the house contains three categories: ≤ 900 ft^2, > 900 ft^2 and $\leq 2,500$ ft^2, and $> 2,500$ ft^2. The combination of these three new variables resulted in 36 housing types that are used for further data mining (e.g., "built before or in 1929, one story, < 900 ft^2" versus "built after 1970, three or more stories, $> 2,500$ ft^2").

Table 1 shows the distribution of these housing types in the United States and the Midwest with respect to the three new variables (i.e., year of the house built, stories, and size). It represents 36 housing types obtained from a cross-tabulation of three variables. It demonstrates different housing types in the United States and the Midwest showing the frequency and percentage of each type.

In the Midwest, the four most common types are two-story houses of 900–2,500 ft^2 built since 1970 (13.96%), two-story houses of 900–2,500 ft^2 built between 1950 and 1969 (11.33%), three or more story houses 2,500 ft^2 or larger built since 1970 (8.04%), and three or more story houses 900–2,500 ft^2 built before 1930 (7.30%). These four types account for roughly 41% of all single-family dwellings in the Midwest (see Table 24 in Appendix F).

After the CEER team divided the housing size into several different categories, homes were categorized into three sizes (i.e., size ≤ 900 ft^2, 900 ft$^2 <$ size $\leq 2,500$ ft^2, and size$> 2,500$ ft^2), as it was more reasonable to create housing archetypes that reflect all the other housing features. Finally, 36 housing types were created as outlined in Table 1.

The creation of the 36 housing types provided a basis for analysis of the relationship between houses and energy consumption. There are four variables in the dataset that can, to a great extent, reflect the energy consumption of housing units: Average Monthly Cost of Electricity, Average Monthly Cost of Gas, Annual Cost of Other Fuels, and Annual Cost of Fuel Oil. The CEER team converted each of these to its monthly cost equivalent and then combined these four variables to create a new variable MEB. Where the total MEBs from all sources were zero, they were excluded since these most likely represented missing values.

Table 1 shows the average MEB of each housing type both in the United States and in the Midwest region. The CEER team found that MEBs usually increased when housing size increased. But, there were some cases to show different relationships between the MEB and the house size. As the type 2 and type 3 in the Midwest, their MEBs decreased when the housing size increased. Similarly, the type 7 and type 8 showed this relationship. The CEER team

therefore analyzed these relationships further using multiple regressional and logistic regressional models (see Section 3.1.2.2).

Based on Table 1, the CEER team created Table 2 to demonstrate 10 housing types that would be common and 10 types that had the highest average MEB. The ideal candidates for a major effort to reduce energy consumption through retrofitting are those housing types that are both very prevalent and highly energy consumptive.

The analysis indicated that the housing types that are very common and energy consumptive in the Midwest are the three or more story houses 2,500 ft^2 or larger built since 1970 (8.04%, type 36), and three or more story houses 900–2,500 ft^2 built between 1930 and 1949 (4.19%, type 17) (see Table 2). The most energy-consumptive types in the nation that have three or more stories, < 900 ft^2, and built before 1930 cover only 0.33% of the entire Midwest housing stock; thus, this type was not seriously considered as one of the prevalent archetypes.

Table 1. Profile of Single-Family Housing Types Overall, by Regions

	Housing Characteristics			Single-Family Housing Types				MEB	
				United States		Midwest		United States	Midwest
	Built	Stories	Size (ft²)	Number	%	Number	%	MEB	MEB
1	≤ 1929	1	≤ 900	433,187	0.56	155,327	0.83	$157.76	$189.00
2	≤ 1929	1	900–2,500	1,251,496	1.61	254,190	1.36	$180.40	$193.11
3	≤ 1929	1	> 2,500	74,142	0.10	9,597	0.05	$194.75	$134.47
4	≤ 1929	2	≤ 900	258,514	0.33	131,713	0.70	$198.59	$185.98
5	≤ 1929	2	900–2,500	1,657,069	2.13	700,506	3.73	$214.41	$206.09
6	≤ 1929	2	> 2,500	295,942	0.38	94,139	0.50	$272.97	$251.62
7	≤ 1929	≥ 3	≤ 900	165,394	0.21	62,675	0.33	$288.97	$274.21
8	≤ 1929	≥ 3	900–2,500	2,901,527	3.74	1,369,578	7.30	$258.95	$226.80
9	≤ 1929	≥ 3	>2,500	1,308,959	1.69	476,601	2.54	$308.87	$260.67
10	1930–1940	1	≤ 900	1,133,601	1.46	218,743	1.17	$154.76	$201.46
11	1930–1940	1	900–2,500	3,103,709	4.00	331,482	1.77	$185.62	$188.86
12	1930–1940	1	>2,500	172,623	0.22	13,682	0.07	$237.27	$246.20
13	1930–1940	2	≤ 900	286,362	0.37	117,344	0.63	$186.00	$162.21
14	1930–1940	2	900–2,500	1,686,570	2.17	640,187	3.41	$210.16	$205.93
15	1930–1940	2	> 2,500	316,849	0.41	90,829	0.48	$265.33	$230.58
16	1930–1940	≥ 3	≤ 900	146,839	0.19	64,508	0.34	$229.39	$211.99
17	1930–1940	≥ 3	900–2,500	1,774,657	2.29	786,362	4.19	$257.05	$237.52
18	1930–1940	≥ 3	>2,500	585,039	0.75	193,299	1.03	$297.66	$247.41
19	1950–1969	1	≤ 900	1,356,383	1.75	331,953	1.77	$155.91	$157.81
20	1950–1969	1	900–2,500	8,628,603	11.11	1,026,499	5.47	$187.28	$199.43
21	1950–1969	1	>2,500	625,399	0.81	59,520	0.32	$245.89	$212.15
22	1950–1969	2	≤ 900	385,051	0.50	167,316	0.89	$186.26	$185.68
23	1950–1969	2	900–2,500	4,861,140	6.26	2,124,857	11.33	$223.09	$198.89
24	1950–1969	2	> 2,500	1,302,142	1.68	386,480	2.06	$268.90	$249.95
25	1950–1969	≥ 3	≤ 900	102,032	0.13	45,098	0.24	$233.89	$163.16
26	1950–1969	≥ 3	900–2,500	1,757,663	2.26	643,720	3.43	$258.32	$222.22
27	1950–1969	≥ 3	> 2,500	644,897	0.83	195,810	1.04	$308.11	$262.65
28	1970–2009	1	≤ 900	1,001,358	1.29	168,561	0.90	$154.16	$158.77

| Housing Characteristics | | | Single-Family Housing Types | | | | MEB | |
| | | | United States | | Midwest | | United States | Midwest |
Built	Stories	Size (ft^2)	Number	%	Number	%	MEB	MEB
29	1970–2009	1	900–2,500	14,765,715	19.02	1,233,130	6.57	$183.21	$179.92
30	1970–2009	1	>2,500	2,059,122	2.65	82,804	0.44	$227.85	$218.72
31	1970–2009	2	≤ 900	240,518	0.31	83,249	0.44	$195.92	$192.84
32	1970–2009	2	900–2,500	9,359,134	12.05	2,619,027	13.96	$203.02	$191.32
33	1970–2009	2	> 2,500	5,527,359	7.12	1,040,646	5.55	$255.78	$214.98
34	1970–2009	≥ 3	≤ 900	82,393	0.11	17,107	0.09	$216.79	$273.53
35	1970–2009	≥ 3	900–2,500	3,370,131	4.34	1,312,707	7.00	$233.63	$219.46
36	1970–2009	≥ 3	> 2,500	4,017,334	5.17	1,507,854	8.04	$291.86	$266.23
Total				77,638,853	100.00	18,757,100		$224.49	$218.24

Note: Single-family houses only for this table.
Source: American Housing Survey (U.S. Census Bureau 2009).

Table 2. Major Types of Houses in the Midwest

Most Common Types	Type Number (From Table 1)	Number of Stories	Size (ft^2)	Year Built	Percent of Total Housing Stock (%)
1st	32	2	900–2,500	Since 1970	13.96
2nd	23	2	900–2,500	1950–1969	11.33
3rd	36	≥ 3	> 2,500	Since 1970	8.04
4th	8	≥ 3	900–2,500	Before 1930	7.30
5th	35	≥ 3	900–2,500	Since 1970	7.00
6th	29	1	900–2,500	Since 1970	6.57
7th	33	2	> 2,500	Since 1970	5.55
8th	20	1	900–2,500	1950–1969	5.47
9th	17	≥ 3	900–2,500	1930–1949	4.19
10th	5	2	900–2,500	Before 1930	3.73
Most Consumptive Types	Type Number (From Table 4)	Number of Stories	Size (ft^2)	Year Built	Monthly Energy Costs
1st	7	≥ 3	≤ 900	Before 1930	$274.21
2nd	34	≥ 3	≤ 900	Since 1970	$273.53
3rd	36	≥ 3	> 2,500	Since 1970	$266.23
4th	27	≥ 3	> 2,500	1950–1969	$262.65
5th	9	≥ 3	> 2,500	Before 1930	$260.67
6th	6	2	> 2,500	Before 1930	$251.62
7th	24	2	> 2,500	1950–1969	$249.95
8th	18	≥ 3	> 2,500	1930–1949	$247.41
9th	12	1	> 2,500	1930–1949	$246.20
10th	17	≥ 3	900–2,500	1930–1949	$237.52
11th	15	2	> 2,500	1930–1949	$230.58
Overall Average					$218.24

Source: AHS (U.S. Census Bureau (2009).

By extracting the two groups of housing types from Table 1, the CEER team also investigated other features of these houses and found significant relationships between some variables and MEB. The identified variables were room air conditioning, central air conditioning, basement, attached garage or carport, and the mean family income, household income, number of residents, number of rooms, and age of householders. For instance, both the high percentage housing types and the high energy consuming housing types have a high percentage with attached garage or carport (84.6 and 82.5%, respectively). Approximately 90.1% of the high energy consuming housing types have a basement, whereas only 37.9% of the most common housing types have it. Income was identified as an important variable relevant to MEB. Both family income and household income of high energy consuming housing types ($104,916 and $107,144, respectively) were significantly higher than the income of the most common housing types ($77,504.06 and $79,469.70, respectively).

This initial analysis showed that house size, number of stories, the year the house was built, air conditioning, basement, and attached garage or carport can be influential architectural variables based on the AHS in determining prevalent archetypes for energy-efficient retrofit.

3.1.2.2 Housing Features Affecting Housing Energy Consumption: Multiple Regression and Logistic Regression Models

The CEER team developed two regression models to examine which housing features have an influence on energy consumption patterns in Midwest houses. The CEER team considered the 21 variables from the original NEWHOUSE dataset as independent variables for these models. The 21 variables are presented in Table 3.

Table 3. Variables for the AHS Analysis

Name	Label	Type of Variable
Afur	Forced air furnace as supplemental heating equip	Nominal
Cokst	Cook stove used as supplemental heating equipment	Nominal
Elect	Electrical units used as supplemental heat equip	Nominal
Hoth	Other equipment used as supplemental heating equip	Nominal
Hpmp	Heat pump used as supplemental heating equipment	Nominal
Plf	Pipeless furnace used as supplemental heating equipment	Nominal
Porth	Portable heaters used as supplemental heating equipment	Nominal
Steam	Steam system used as supplemental heating equip	Nominal
Stove	Wood stove used as supplemental heating equipment	Nominal
None	No supplemental heating equipment	Nominal
Rooms	# of rooms in unit	Scale
REGIONR	Census region	Nominal
Airsys	Central air conditioner	Nominal
zinc2	Household income	Scale
HEQUIP	Main heating equipment	Nominal
BUILTR	Year unit was built	Nominal
Fplwk	Unit has usable fireplace	Nominal
CELLAR	Unit has a basement	Nominal
Stories	Number of stories in house	Scale
Unitsf	Square footage of unit	Scale
Per	# of persons in household	Scale

In order to make all independent variables suitable for the regression, the CEER team recoded them into dummy variables. In most of the cases, the CEER team assigned 1 as "yes" and 0 as "no." For the variable HEQUIP (Main Heating Equipment), which has 14 categories, "Forced warm-air furnace with ducts and vents to individual rooms" was taken as the comparison category and dummy variables were created for each of the other categories. For BUILTR (Year Unit was Built), "house built after 1970" was taken as the comparison category and dummy variables were created for each of the other categories. For REGIONR (Census Region), region2 (Midwest) was used as the comparison category and dummy variables were created for each of the remaining regions. For zinc2 (Household Income), although it is a scale variable, it was divided into five categories by the level of income (20 for each) and the middle one (i.e. Household Income in the 60 Highest Level) was taken as the comparison category, because the

normal distribution of this category might make it unsuitable for the multiple regression. Additionally, the variable "unitsf" (square footage of unit) was divided by 1000 so that the Betacoefficient in the final model would not be too small.

The initial analyses included all house characteristics. Many, however, when controlling for the influences of other variables, had no significant independent effect on energy consumption costs and were therefore eliminated from subsequent models. This process was repeated until only the variables remained in the model whose net effects on the dependent variable were significant.

Table 4 presents a multiple regression model with the adjusted R-square of 0.182. The dependent variable (Y) of this model was MEB. Although R-square was low, the model was statistically significant at a significance level of 0.001. Since this model included many relevant independent variables to examine their effects on home energy consumption, the R-squared value was not that high. If some variables with small Beta coefficient values were removed, the R-squared value could increase. But the main purpose of the regressional model was to show any significant relationships between independent variables (i.e., physical characteristics of homes) and monthly energy consumption. The model therefore did not remove certain variables in order to improve the R-square value.

Table 4. Significant Variables To Determine Housing Energy Consumption in the Midwest

Model			Multiple Regression Model		Logistic Regression Model	
Overall			R-Square = 0.184 Adjusted R-Square = 0.182	Sig 0.00	Cox and Snell R-Square = 0.484 Nagelkerke R-Square = 0.717 −2 Log Likelihood = 3426.551	
Variables			Beta Coefficient	Sig	Beta Coefficient	Sig
Constant			40.841	0.000	−16.391	0.000
Significant Variables	SteamD	Steam system used as supplemental heating equipment	90.461	0.004	N/A	N/A
	HEQUIP2	Main heating system: Steam or hot water system with radiators OR other system using steam or hot water	14.965	0.001	0.619	0.001
	HEQUIP3	Electric heat pump	−26.104	0.000	N/A	N/A
	HEQUIP4	Built-in electric baseboard heating or electric coils in floors, ceilings, or walls	−24.462	0.001	N/A	N/A
	HEQUIP9	Wood burning, pot belly, or Franklin stove	−64.008	0.000	N/A	N/A
	rooms	Number of rooms in unit	16.837	0.000	0.306	0.000
	per	Number of persons in household	12.345	0.000	N/A	N/A
	Built1D	House built in 1929 or earlier	23.706	0.000	4.336	0.000
	Built2D	House built between 1930 and 1949	29.012	0.000	N/A	N/A
	Built3D	House built 1950 and 1969	17.097	0.000	1.149	0.000
	Stories	Number of Stories in house	10.991	0.000	3.244	0.000
	Unitsf1000	Square footage of unit divided by 1000	1.603	0.001	1.016	0.000
	hhincome 80/Zinc1000	Household income in the 80 highest level	−7.592	0.004	0.002	0.009
	fplwk	Unit has usable fireplace	−11.482	0.000	0.449	0.000
	FullB	With a basement under all of the house	−10.789	0.001	0.212	0.000
	PartB	With a basement under part of the house	−14.114	0.000	0.686	0.002
Dependent Variable		Multiple Regression: Y = MEB Logistic Regression: Y = LRMEB: 1- type of houses whose overall MEB ranks in the top 25% group; 0 - types of houses whose overall MEB does not rank in the top 25% group.				

The equation drawn from this analysis is:

$Y = 40.841 + 90.461\ SteamD + 14.965\ HEQUIP2 - 26.104\ HEQUIP3 - 24.462\ HEQUIP4 - 64.008\ HEQUIP9 + 16.837\ rooms + 12.345\ per + 23.706\ Built1D + 29.012\ Built2D + 17.097\ Built3D + 10.991\ Stories + 1.603\ Unitsf1000 - 7.592\ hhincome80 - 11.482\ fplwk - 10.789\ FullB - 14.114\ PartB$

This equation shows explanatory contribution of several independent variables toward energy consumption. The variable of year house was built named "Built2D (House built between 1930 and 1949)" is the one that has the highest positive Beta coefficient. Therefore, there might be more houses built between 1930 and 1949 that consume more energy as a total than houses built in 1929 or earlier in the Midwest. Refer to Table 4 for explanatory variables affecting the MEB in the multiple regression model and Table 25 in Appendix G for more detailed results about this model.

The CEER team also developed a binary logistic regression model for the cases in the Midwest to predict monthly energy consumption. In this model, the dependent variable LRMEB derives from the group of high energy consumption housing types. Most of the independent variables used in running the model are the same as the independent variables used in the multiple regression model. The only difference is that the variable "zinc2" (household income) was taken as a scale variable and it was divided by 1000.

The Nagelkerke R-squared value from the logistic regression model was about 0.717, which was higher than the adjusted R-squared value of the multiple regression model.

The equation for this model is presented below.

$Log\ (Odds\ OMEB) = 0.619\ HEQUIP2 + 0.306\ rooms + 3.244\ Stories + 1.016\ unitsf1000 + 0.002\ zinc1000 + 4.336\ Built1D + 1.149\ Built3D + 0.212\ FullB + 0.686\ PartB + 0.449\ fplwkD - 16.391$

The logistic regression model included the independent variable HEQUIP2, which indicates the house has a steam or hot water system with radiators or other system using steam or hot water. Built2D is not included in this model, which means that year built between 1930 and 1949 in the Midwest are less likely to have an influence on whether the house should be classified in the high energy consuming group or not.

There are several differences between the multiple regression model and the logistic regression model. First, the independent variables "Full Basement" and "Part Basement" have a positive relationship to the dependent variable according to the logistic regression model, while the relationship is negative in the multiple regression model. This means that these two variables seemed to contribute toward increasing energy consumption in the logistic regression model while decreasing energy consumption in the multiple regression model. Second, the variable "Stories" has a much larger influence on the dependent variable in the logistic regression than it has in the multiple regression model. But, this variable seemed to contribute toward increasing energy consumption of a house. In addition, the variable per (number of persons in household) is not significant in the logistic regression model, while it is in the multiple regression model.

Based on the general housing type analysis and regression analyses, the CEER team determined that Main Heating System, Number of Rooms in Unit, House Built in 1929 or earlier, or between 1950 and 1969, Number of Stories in House, Square Footage of Unit, Fireplace in Unit, and Basement in House should be determinants affecting energy consumption in Midwest houses. They were expected to be important factors to determine housing archetypes for energy-efficient retrofitting. Additionally, the analysis proved the effects of household characteristics (i.e., income) on energy consumption costs of housing units independent of other characteristics.

3.2 Taxonomy of Architectural Styles of Michigan Houses
3.2.1 Process and Data Sources to Create the Housing Style Taxonomy
The process for creating a housing taxonomy was described in Section 2.3. This section describes the taxonomy applicable specifically to Michigan and was designed for use with the two case study cities in Michigan and for direct application to test home research conducted by CEER in Grand Rapids.

Table 18 shows the initial taxonomy with examples across the United States and is described in Section 3.2.3. Table 5 shows the Michigan-focused taxonomy and is presented in Section 3.2.4.

3.2.2 Definition of Housing Styles
McAlester and McAlester (1984) defined "style" as architectural fashion applied to house exteriors and interiors (p. 5). They also identified two broad categories of American housing: "folk houses" built by non-professionals and "styled houses" built by professional builders.

Styled houses reflect architectural fashions adapted from varied design elements and motifs and could be inspired by specific cultures, historic periods, or regional and geographical characteristics. "Folk" houses may be more various, more vernacular, may reflect local materials, and were typically built without trained professionals. Generally, the CEER team focused on "styled" houses in creating the taxonomy, although some examples do reflect some aspects of "folk" or "vernacular" architecture.

McAlester and McAlester (1984, p. 102) identified "colonial houses" built from 1600s as the first period of "styled" houses in the United States. They also identified five eras (periods) and numerous style examples of houses, providing images and text to describe features (see Table 18).

3.2.3 Architectural Style Taxonomy of American Houses
Table 18 in Appendix B lists time periods and their associated styles. The styles listed by time period in Table 18 were initially identified from McAlster and McAlster (1984), and then compared to the other sources listed in Appendix C: Taxonomy of Architectural Styles of Michigan Houses.

Generally, the CEER team found a degree of consistency between style categories and their various sources. However, dates associated with some styles varied among sources. As a result, some house styles were listed in multiple periods. For instance, the octagon style was categorized as a Romantic House style (1820–1880) by McAlster and McAlster (1984), but it was categorized as a Victorian House style by several other sources.

Similarly, the time periods and names of some eras vary somewhat among sources. For example, McAlster and McAlster (1984) grouped 12 styles into "Eclectic houses (1880–1940)" while other sources categorized these houses into more specific groups such as gilded age (1880–1929), Neoclassical (1890–1930) or early 20th century (1901–1945), modernist (1930–present), and neo-houses (1965–present). The CEER team compiled this various information and finalized the list of housing styles as shown in Table 18 in Appendix B.

3.2.4 Architectural Style Taxonomy of Michigan Houses

After constructing the initial taxonomy of American houses, it was reviewed by housing style experts and reduced by the research team, in order to create a Michigan-specific taxonomy that could be used as a basis in the two case study Michigan cities and for selection of BA research test homes in Grand Rapids.

Since the target of our research was to determine which housing archetypes were prevalent and therefore could serve for selection of effective test homes, the CEER team examined identifying architectural features of common Michigan styles through images, literature, and archives. Additionally, the team viewed a number of field examples and photographed them in order to create a visual library.

For each housing style common to Michigan, CEER prepared a summary including descriptions and images representing the style. For demonstration of the format, two examples are included below. Appendix C contains similar information for other common styles in Michigan.

3.2.4.1 Greek Revival (1825–1860s)

Sometimes referred to as the National style; widely popular in this time period; emerged as a style for public buildings in Philadelphia; fashionable Grecian style that spread through carpenters' guides and pattern books; symmetrical in shape; prominent use of columns on the façade or entry porch.

Major features: classical pediment over entry porch; symmetrical shape; heavy cornice, wide/plain frieze; bold/simple moldings; glazed door surround at main entrance; classical or square columns on front façade or at entry porch; decorative pilasters; three-part Palladian windows (McAlester and McAlester 1984, pp. 179–180). Figure 1 shows a prototype of a Greek Revival home; Figure 2 and Figure 3 show variations of this style.

Figure 1. Prototype of Greek Revival

(Original Image from McAlester and McAlester 1984, p. 178) adapted/ illustrated by S. Space

Figure 2. A variation of Greek Revival

Photo by S.-K. Kim

Figure 3. A variation of Greek Revival

Photo by A. Harrell-Seyburn

3.2.4.2 Ranch (1935–present)

Prevalent style during the 1950s and 1960s; drew its influence and is loosely based on early American Spanish Colonial, Prairie, and Craftsmen styles; features long single-story façades; often incorporates attached garage. (See Figure 4 and Figure 5 below.)

Features: asymmetrical one-story shapes; low-pitched roofs; roofs are hipped, cross-gabled, or side-gabled; moderate to wide eave overhanging; typically included wood or brick cladding; porches have decorative iron or wooden supports; ribbon windows and a large picture windows in living room are typical (see Figure 4 and Figure 5) (McAlester and McAlester 1984, pp. 477–478).
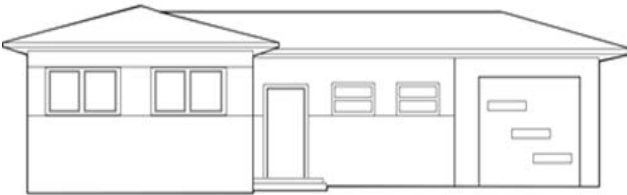
Figure 4. Prototype of a Ranch style house

(Original image from McAlester and McAlester 1984, p. 476)
adapted/illustrated by S. Space

Figure 5. Example of a Ranch style house

Photo by S.-K. Kim

Table 5 shows typical architectural styles for homes in Michigan and the Great Lakes regions. Several refinements are included in the Michigan taxonomy, which presents listing styles as "Modern," "Neoeclectic," and "Contemporary Folk" in accordance with the classifications of McAlester and McAlester (1984). "Modern" includes five styles: Minimal Traditional, Ranch, Split-Level Ranch, Contemporary, and Shed. "Neoeclectic" includes seven styles: Mansard, Neocolonial, Neo-French, Neo-Tudor, Neo-Mediterranean, Neoclassical Revival, and Neo-Victorian. "Contemporary Folk" includes four styles: Mobile homes (currently referred to as manufactured housing), Quonset Huts, A-Frame, and Geodesic Domes. Among these modern styles, Ranch, Split-Level Ranch, Manufactured Housing, Neoclassical Revival, and Neo-Victorian are architectural styles common to Michigan and the Midwest.

Styles found in Michigan are highlighted in Table 6 and include French Colonial (1700–1830s), Green Revival (1825–1860s), Gothic Revival (1840–1880s), Italianate (1840–1885), Stick (1860–1870s), Queen Anne (1880–1900s), Folk Victorian (1870–1910), Colonial Revival (1880–1955), Neoclassical (1895–1950), Tudor (1890–1940), Italian Renaissance (1890–1935), Prairie (1900–1920), Craftsman (1905–1930), Ranch (1935–present), Split-Level Ranch (1935–present), Neoclassical Revival (1965–present), and Neo-Victorian (1965–present).

Table 5. Architectural Styles of Michigan Houses

Period	Source	Styles	Periods	Available in Michigan
1600–1820 Colonial Houses	McAlester and McAlester (1984)	Postmedieval English	1600–1700s	– Not typical
		Dutch Colonial	1625–1840s	– Not typical
		French Colonial	1700–1830s	– Available in Great Lakes (p. 122)
		Spanish Colonial	1600–1850s	– Not typical
		Georgian Colonial	1700–1780s	– Not typical
		Adam	1780–1820s	– Not typical
		Early Classical Revival	1770–1830s	– Not typical
	From other sources	New England Colonial	1500–1600s	– Not typical
		German Colonial	1600–1700s	– Available in Ohio, not common in Michigan
		Federal and Adams	1780–1830s	– Very rare
1820–1880 Romantic Houses	McAlester and McAlester (1984)	*Greek Revival*	1825–1860s	– Popular in Ohio, Illinois, Michigan, Wisconsin (p. 182)
		Gothic Revival	1840–1880s	– Available in Michigan (p. 200)
		Italianate	1840–1885	– Popular in the Midwest (p. 212)
		Exotic Revivals	1835–1890s	– Not typical (p. 231)
		Octagon	1850–1870s	– Very rare but available in the Midwest (p. 235)
	From other sources	Call the above styles as "Classical Styles"		
1860–1900 Victorian Houses	McAlester and McAlester (1984)	Second Empire	1860–1880s	– Rare but available in the Midwest (p. 242)
		Stick	1860–1870s	– Gabled examples popular in Michigan (p. 256)
		Queen Anne	1880–1900s	– Nationally prevalent style (p. 266)
		Shingle	1880–1900s	– Not typical
		Richardsonian-Romanesque	1860–1870s	– Not typical
				– Not typical
		Folk Victorian	1870–1910s	– Common throughout the country (p. 310)
	From other sources	Eastlake House	1880–1900s	– Available/ One type of Queen Anne style
		Victorian Sticks	1860–1870s	– Available/ Another name of Stick style
1880–1940 Eclectic Houses	McAlester and McAlester (1984)	*Colonial Revival*	1880–1955	– Nationally prevalent style (p. 324)
		Neoclassical	1895–1950	– Popular as Colonial Revival (p. 343)
		Tudor	1890–1940	– Available and nationally popular (p. 355)
		Chateauesque	1880–1910	– Not typical
		Beaux Arts	1885–1930	– Not typical
		French Eclectic	1915–1945	– Not typical
		Italian Renaissance	1890–1935	– Available in Michigan and Great Lakes (p. 388)
		Mission	1890–1920	– Not typical
		Spanish Eclectic	1915–1940	– Very rare in Michigan
		Monterey	1925–1955	– Very rare in Michigan
		Pueblo Revival	1910–present	– Very rare in Michigan
		Prairie	1900–1920	– Popular in Chicago and Midwestern cities (p. 440)
		Craftsman	1905–1930	– Nationally popular (p. 454)
		Modernistic	1920–1940	– Not typical
		International	1925– present	– Not typical
		Beaux Arts	1885–1930	– Not typical
	From other sources [1]	Renaissance Revival	1890–1915	–Very rare
		Tudor Revival	1910–1940	– Popular in Michigan
		French Normandy	N/A	– Rare in Michigan, mostly in Traverse City
		French Provincial	N/A	– Several in Michigan

Period	Source	Styles	Periods	Available in Michigan
		French Eclectic	N/A	– Available but not common
		Colonial Revival	1880–1955	–Popular in Michigan
		Prairie Style	1900–1920	– Available but not popular in Michigan
		Craftsman	1905–1930	– Popular as bungalow or American Foursquare
		Art Moderne	1920–1945	– Available but not common
		Bauhaus	1920–1945	– Available but not common
		International	1925– present	– Very rare
Modern Since 1940	McAlester and McAlester (1984)	Modern		– Available but not common
		Minimal Traditional		
		Ranch	1935–present	– Popular in Michigan (p. 477)
		Split-Level		– Popular in Michigan (p. 477)
		Contemporary		– Available but not common
		Shed		– Very rare
		Neoeclectic		
		Mansard		– Very rare
		Neocolonial	1965–present	– Very rare
		Neo-French		– Very rare
		Neo-Tudor		– Available
		Neo-Mediterranean		– Very rare
		Neoclassical Revival		– Available
		Neo-Victorian		– Available
		Contemporary Folk		
		Mobile Homes		– Available in Michigan
		Quonset Huts	1940–present	– Very rare
		A-Frame		– Very rare
		Geodesic Domes		– Very rare

Note 1. The availability and commonality of housing styles from other sources under the 1880–1940 Eclectic. House categories were confirmed by staff members of the Michigan State Historic Preservation Office.

Table 6. Common Styles and Periods of Michigan Houses

Period	Styles	Periods
1600–1820 Colonial Houses	French Colonial	1700–1830s (not common for Michigan)
1820–1880 Romantic Houses	Greek Revival Gothic Revival Italianate	1825–1860s 1840–1880s 1840–1885
1860–1900 Victorian Houses	Stick Queen Anne Folk Victorian	1860–1870s 1880–1900s 1870–1910s
1880–1940 Eclectic Houses	Colonial Revival Neoclassical Tudor Italian Renaissance Craftsman Tudor Revival	1880–1955 1895–1950 1890–1940 1890–1935 1905–1930 1910–1940
Since 1940	Ranch Split-Level Neoclassical Revival Neo-Victorian	1935–present 1965 present

Source: McAlester and McAlester (1984)

3.2.5 General Characteristics of Common Housing Styles in the Midwest

Table 6 identifies time periods and common architectural "styled" homes for Michigan housing and is followed by discussion of their characteristics. All information is based on McAlester and McAlester (1984).

The library of housing styles was developed to create a common understanding of date ranges and architectural style features useful in classifying homes for energy retrofit research. The library of housing styles was used in case studies of Ann Arbor and Grand Rapids, along with housing census data, public information, and Zillow.com to characterize and describe local housing stocks and to determine prevalent archetypes for the two local markets.

3.3 Local Case Studies—Michigan
3.3.1 Housing Market Analysis—Midwest and Michigan

The CEER team undertook case studies of two cities, Ann Arbor and Grand Rapids, in order to compare local markets with national and regional census data and to explore methods for determining housing archetypes within a local market. The Grand Rapids study was centered on identifying recommended archetypes for BA energy retrofit research being conducted in Grand Rapids by the CEER team.

The previous Section 3.1 presented the analysis of the 2009 AHS data and reported national and regional housing stock characteristics. This section briefly presents housing market characteristics for a four-state Great Lakes sub-region, as well as data from Ann Arbor and Grand Rapids from the U.S. Census Bureau's American Fact Finder available at http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.

Table 7 shows occupancy rates, number of houses per period, housing heating fuel, and other characteristics including plumbing and kitchen facilities for four states as well as Ann Arbor and Grand Rapids. Overall, the census data indicated Michigan had 4,529,681 housing units in 2012. Ann Arbor and Grand Rapids had 49,871 and 81,595 units, respectively.

Table 7. Selected Characteristics of Housing Stock in the Target Areas

Items		United States	Great Lakes Sub-Regions				Target Cities	
			Michigan	Illinois	Ohio	Indiana	Ann Arbor	Grand Rapids
Housing Stock	Total	130,038,080 (100%)	4,529,680 (100%)	5,267,614 (100%)	5,107,273 (100%)	2,778,459 (100%)	49,871 (1.08%)	81,595 (1.79%)
Occupied Units	Total	114,235,996 (100%)	3,843,997 (100%)	4,769,951 (100%)	4,552,270 (100%)	2,465,402 (100%)	45,166 (100%)	74,368 (100%)
	Owner-occupied	76,089,650 (66.6%)	2,852,374 (74.2%)	3,300,691 (69.2%)	3,149,052 (69.2%)	1,763,781 (71.5%)	20,976 (46.4%)	44,436 (59.1%)
	Renter-occupied	38,146,346 (33.4%)	991,623 (25.8%)	1,469,260 (30.8%)	1,403,218 (30.8%)	701,621 (28.5%)	24,190 (53.6%)	29,932 (40.9%)
Year Structure Built	Total	130,038,080 (100.0%)	4,529,680 (100%)	5,267,614 (100%)	5,107,273 (100%)	2,778,459 (100%)	49,871 (100%)	81,595 (100%)
	2000 or later	16,556,490 (12.8%)	421,398 (9.3%)	530,429 (10.1%)	459,143 (9.0%)	326,358 (11.8%)	2,784 (5.6%)	3,180 (4.0%)
	1990–1999	18,316,301 (14.1%)	580,582 (12.8%)	560,625 (10.6%)	595,302 (11.7%)	403,999 (14.5%)	5,381 (10.8%)	5,250 (6.4%)
	1980–1989	18,473,041 (14.2%)	450,633 (9.9%)	468,049 (8.9%)	456,878 (8.9%)	281,875 (10.1%)	5,096 (10.2%)	5,418 (6.6%)
	1970–1979	21,353,306 (16.4%)	709,303 (15.7%)	775,239 (14.7%)	734,288 (14.4%)	402,219 (14.5%)	9,402 (18.9%)	6,390 (7.8%)
	1960–1969	14,808,721 (11.4%)	549,176 (12.1%)	635,128 (12.1%)	633,665 (12.4%)	324,800 (11.7%)	10,142 (20.3%)	9,045 (11.1%)
	1950–1959	14,654,704 (11.3%)	700,319 (15.5%)	707,982 (13.4%)	753,012 (14.7%)	327,141 (11.8%)	6,879 (13.8%)	13,038 (16.0%)
	1940–1949	7,526,519 (5.8%)	388,636 (8.6%)	372,084 (7.1%)	358,691 (7.0%)	178,238 (6.4%)	2,832 (5.7%)	7,523 (9.2%)
	1939 or earlier	18,348,998 (14.1%)	729,633 (16.1%)	1,218,078 (23.1%)	1,16,294 (21.9%)	533,829 (19.2%)	7,333 (14.7%)	31,751 (38.9%)
Housing Heating Fuel	Occupied housing units	114,235,996 (100%)	3,843,997 (100%)	4,769,951 (100%)	4,552,270 (100%)	2,465,402 (100%)	45,166 (100.0)	73,118 (100.0%)
	Utility gas	57,018,485 (49.9%)	2,997,239 (78.0%)	3,855,578 (80.8%)	3,099,918 (68.1%)	1,552,065 (63.0%)	38,551 (85.4%)	67,102 (91.8%
	Bottled, tank, or liquefied petroleum gas	6,146,376 (5.4%)	353,528 (9.2%)	205,421 (4.3%)	259,832 (5.7%)	195,533 (7.9%)	580 (1.3%)	674 (0.9%)

Items	United States	Great Lakes Sub-Regions				Target Cities	
		Michigan	Illinois	Ohio	Indiana	Ann Arbor	Grand Rapids
Electricity	39,066,347 (34.2%)	270,560 (7.0%)	636,626 (13.3%)	912,811 (20.1%)	614,842 (24.9%)	5,473 (12.1%)	4,442 (6.1%)
Fuel oil, kerosene, etc.	8,073,165 (7.1%)	78,658 (7.0%)	14,946 (0.3%)	149,703 (3.3%)	34,460 (1.4%)	224 (0.5%)	210 (0.3%)
Goal or coke	135,257 (0.1%)	1,024 (0.0%)	739 (0.0%)	3,960 (0.1%)	3,376 (0.1%)	10 (0.0%)	36 (0.0%)
Wood	2,249.635 (2.0%)	105,886 (2.8%)	22,417 (0.5%)	82,645 (1.8%)	47,245 (1.9%)	64 (0.1%)	131 (0.2%)
Solar energy	38,010 (0.0%)	675 (0.0%)	735 (0.0%)	753 (0.0%)	593 (0.0%)	0 (0.0%)	13 (0.0%)
Other fuel	483,454 (0.4%)	26,326 (0.7%)	18,974 (0.4%)	30,536 (0.7%)	11,675 (0.5%)	189 (0.4%)	321 (0.4%)
No fuel used	1,025,267 (0.9%)	11,101 (0.3%)	14,515 (0.3%)	12,112 (0.3%)	5,613 (0.2%)	75 (0.2%)	189 (0.3%)
Other — Total occupied	114,235,996 (100%)	3,843,997 (100%)	4,769,951 (100%)	4,552,270 (100%)	2,465,402 (100%)	45,166 (100%)	73,118 (100%)
Lacking complete plumbing facilities	602,324 (0.5%)	15,949 (0.4%)	20,666 (0.4%)	19,506 (0.4%)	8,666 (0.4%)	188 (0.4%)	803 (1.1%)
Lacking complete kitchen facilities	899,189 (0.8%)	23,730 (0.6%)	33,697 (0.7%)	36,438 (0.8%)	14,928 (0.6%)	276 (0.6%)	1,067 (1.5%)

Source: All data sets are from http://factfinder2.census.gov - U.S. Census Bureau (2010). Selected housing characteristics 2006–2010 American Community Survey 5-Year Estimates

Figure 6 graphically depicts home construction by decade. The housing stocks in Ann Arbor and Grand Rapids are both slightly older than that of Michigan with 5.6% and 3.9% of homes, respectively, built after 2000 and 94.5% and 96% built before 2000. About 36.2% of homes were built from 1940–1969 and 38.4% were built from 1970–1999 in Michigan. Similarly, more than 36% of homes were built from 1940–1969 in Ann Arbor and Grand Rapids, respectively, and 39.9% and 20.8% of homes were built in Ann Arbor and Grand Rapids, respectively, from 1970–2000.
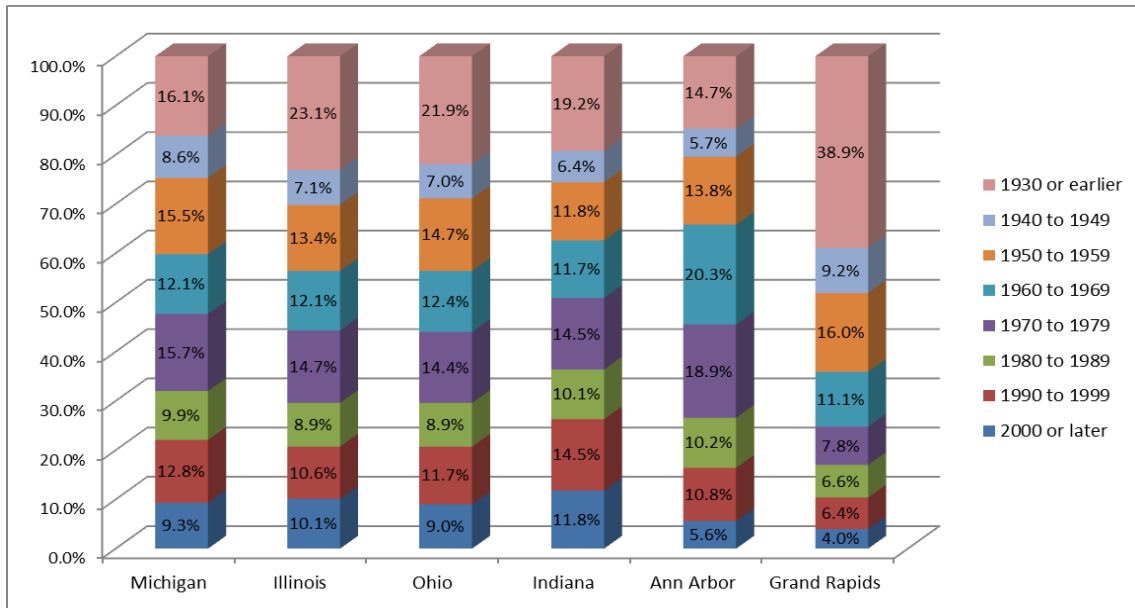
Figure 6. Construction eras of existing homes

(The graph was created by S. Kim based on the U.S. Census Bureau (2010)
Selected housing characteristics 2006–2010 American Community Survey 5-Year Estimates)

It should be noted that for this analysis Ann Arbor and Grand Rapids were taken to be the areas within their city limits, and therefore the statistics do not reflect suburban growth in outlying communities. Overall, Grand Rapids reflects a larger number of older homes (before 1939 and to 1969) than do Ann Arbor and the state of Michigan as a whole. More than 75% of Grand Rapids housing was constructed before 1969 and was likely originally constructed with little or no wall insulation, minimal roof insulation, no basement insulation, and single-glazed windows.

3.3.2 Case Study—Ann Arbor, Michigan

Ann Arbor was selected as the first case study city. Available public information was viewed, input from housing experts was obtained, market site visits were conducted, and the housing stock in Zillow.com was reviewed. Data from each source were used together to determine the prevalent archetypes for the Ann Arbor market. The housing taxonomy of architectural styles and features described in Section 3.2 was used in determining archetypes for this the local market.

3.3.2.1 Investigation of Historical and Social Background

Understanding the historical growth patterns of a city can help in characterizing a local market and provides a preview to the age of structures likely found within individual neighborhoods.

Once these growth patterns are understood, they can be confirmed with local housing experts, published sources, and on-the-ground neighborhood visits. In order to understand city boundaries, growth patterns by era for the city, and its structure of neighborhoods the CEER team used published articles and maps to construct a brief history of the city.

Ann Arbor was initially settled by European Americans in 1824 (Ferraro 1996), had a population of 14,500 in 1900, and grew to 114,024 by 2000 (Shackman 2002). From 1945 to 1960, the city doubled in area (Marwil 1987) and residential neighborhoods and shopping centers were developed on the periphery of the city. Since 1950, more than 40,000 dwellings have been built (Marwil 1987).

3.3.2.2 Meetings With Local Housing Experts
The OSR met with housing experts in separate meetings including realtors and city officials to discuss and obtain information on neighborhoods and archetypes within Ann Arbor. Meetings were conducted with two Ann Arbor realtors, each of whom had more than 30 years professional experience in listing, appraising, and selling homes in Ann Arbor.

The purpose of the meetings was to determine if there were types of homes in the area that account for a significant proportion of the housing stock and would be likely to benefit from an energy retrofit. Two types were identified: "Old West Side Charmers" and "Southwest Quadrant Ranches." Within that area, the "Charmers" are midsized homes of more than one story built before 1930.

The "Old West Side Charmers" fit neatly into the two significant energy cost categories discussed in Section 3.1—built prior to 1930 and two or more levels. This type accounts for 8% of the nation's dwellings, 15% of homes in the Midwest, and 17% of Ann Arbor residences.

The post-war (1950–1969) ranches constitute 14% of the national housing stock and 18% of Ann Arbor's homes, but only 8% of the houses in the Midwest region. The Ann Arbor market varies somewhat from the Midwest as a whole with approximately 38% of Ann Arbor's housing built in the period 1950–1969, compared to 28% in the Midwest. The Ann Arbor case study indicates local markets can vary from state or regional housing data. Understanding these local variations can help to focus local energy retrofit programs based on the housing distribution.

3.3.2.3 Review of Public Information
The CEER team and OSR reviewed public information, including census documents and housing reports for Ann Arbor furnished by the Michigan Historic Preservation Office (Ferraro, 1996) to establish age distribution of housing units and numbers by decade. Census data were presented in Section 3.3.1.

One of the housing reports for this city was the Ann Arbor Intensive Survey (Ferraro, 1996) conducted of the Northside Neighborhood and included all structures within an 85-acre area. The document is an inventory of all structures in this historic neighborhood written for the purpose of establishing a local historic district in accordance with National Register requirements. The Michigan State Historic Preservation Office furnished the research team with this survey as a resource to determine prevalent styles in Ann Arbor. The report was completed in 1996.

The survey was useful to the CEER since it gave a close-up profile of this section of the city and also allowed the team to apply the housing taxonomy. The research team reviewed the data from the Intensive Survey, and consolidated the data into a spreadsheet by address, year, architectural style, foundation material, exterior wall material, and roof materials for each of the 240 structures included in the survey (see Table 21). The team also summarized the findings of this report, which are presented in Appendix D.

3.3.2.4 Site Visits of Neighborhoods

Site visits were conducted of key neighborhoods with well-defined archetype groups in order to observe the housing stock and correlate with the housing taxonomy. Figure 7 shows examples that characterize the Old West Charmers and Southwest Quadrant Ranches. The Southwest Quadrant Ranches were one-story midsized homes, generally built during 1950–1969 and are shown in Figure 8.

Figure 7. Examples of "Charmers" in Ann Arbor

(Photos by N. Ehrlich)

Figure 8. Examples of "Southwest Quadrant Ranches" in Ann Arbor

(Photos by N. Ehrlich)

3.3.2.5 Analysis of Current Housing Stock Through Real Estate Sources

In addition to the general housing market characteristics based on census data, the Intensive Housing Survey report, and site visits, the CEER team conducted an analysis of current real estate listings available from Zillow.com, an online real estate search tool. City properties currently for sale, recently sold, and for rent were reviewed. Zillow listings include a variety of data about each individual property file, including year built, price, square foot area, exterior and interior photos, and narrative descriptions of its features and improvements. A variety of filters are available that allowed sorts to be run by decade in which homes were built, square footage, price range, and lot size. Reviewing the photos of individual homes allowed for matching of individual homes to the housing taxonomy styles presented in Section 3.2.

The CEER team used the Zillow tools to view photos and details on individual homes for sale, for rent, or recently sold. For Ann Arbor in excess of 3,000 properties were listed representing about 7% of the entire housing stock. The Zillow search yielded 2,933 "recently sold," 524 "for sale," and 66 "rental" homes in Ann Arbor on August 8, 2012.

The CEER team matched the distribution of housing stock identified by Zillow.com by decade to the Census Bureau data and found there was an approximate match between the Zillow-filtered searches and the distribution of homes by decade built from the census data (reported in Section 3.3.1). Table 8 below shows Zillow data for homes built before 1939 as 20% of the dataset, while census data show 14.7% for this date range. Zillow data show 43% of the dataset for the period 1940–1969, while the census data show 39.8%. There was some variation in homes for the periods 1970–1999 and 2000–2012, with Zillow showing 25% and 12% for these periods and the census data showing 39.9 and 3.9%.

Table 8. Distribution of Recently Sold Homes Ann Arbor

Construction Eras	Zillow Data		Zillow Data Subtotals	Census Ann Arbor	
1800–1899	25	1%			
1900–1910	159	5%			
1911–1920	101	3%	20%	Before 1939	14.70%
1920–1929	192	7%			
1930–1939	117	4%			
1940–1949	212	7%			
1950–1959	505	17%	43%	1940–1969	39.80%
1960–1969	535	18%			
1970–1979	333	11%			
1980–1989	173	6%	25%	1970–1999	39.90%
1990–1999	236	8%			
2000–2012	345	12%	12%	2000–2012	5.5%
Total	2,933	100%	100%	Total	100.0%

(Source: www.zillow.com)

While the Zillow data do not exactly match the distribution of census data, there was a sufficient relationship that the Zillow data likely approximate a reasonable picture of the housing Ann Arbor stock. Conducting a Zillow review to assess housing archetype distribution when combined with actual census data was a relatively quick means to characterize a local market.

The CEER team viewed a sampling of homes in Zillow.com by decade (refer to Appendix E) and determined that in terms of house forms, most homes built before 1930 are multistory block forms, homes built between 1930 and 1949 are one and half- or two-story block forms. Many houses in this period are 1½-story Cape Cods, which are simple block house forms. A majority of homes built between 1950 and 1979 are one-story ranches or split-level ranches, which are also simple block forms. The forms become more complex for houses built between 1980 and 1999 having more variations in housing shapes. For more information about housing shapes, please refer to Appendix E. The house size becomes larger for this period. Houses built after 2000 become smaller and return to simple forms. A majority of houses built after 2000 had multiple stories with a mix of simple and complex forms.

3.3.2.6 Analysis—Ann Arbor

The CEER team utilized the housing taxonomy, census data, public information, information from housing experts, and the Zillow tool-filtered searches to identify prevalent home types for energy retrofit research for Ann Arbor.

Table 9 below shows results from the logistic regression analysis presented in Section 3.1. The 10 factors listed here all have a significant relationship to energy cost. The two large Beta coefficients indicate that the older, multistory homes—the Charmers—are the most likely to benefit from retrofitting. The CEER team also noted that square footage is a salient factor—bigger houses likely use more energy; thus, targeting bigger houses for energy-efficient retrofit can bring more energy saving. If the team adds in larger old multistory homes, the percentage of those in the Midwest rises to 14%.

Table 9. Significant Variables for the Logistic Regression Models

Exp (Beta) Coefficient	Variables
76.428	House built in 1929 or earlier
25.646	Number of Stories in house
3.154	House built between 1950 and 1969
2.763	Square footage of unit divided by 1000
2.662	With a basement under all of the house
1.985	With a basement under part of the house
1.858	Main heating system: steam or hot water
1.566	Unit has usable fireplace
1.358	Number of rooms in unit
1.002	Household income divided by 1000

Census data showed the age distribution by decade with 14.7% of housing built before 1939, 39.8% from 1940–1969, 39.9% from 1970–1999, and 5.5% since 2000. From the Zillow.com listings, field site visits, and meetings with housing experts, it is apparent there is diversity in the housing stock during these time periods. However, there are certain archetypes that are identifiable, common, and offer good potential as subject archetypes for energy retrofit research.

Two general archetypes can be used to describe almost the entire housing stock for houses built before 1930 and have the following characteristics: constructed before 1930, balloon framed, multistory, 900–2,500 ft^2, relatively vertical orientation reflecting small urban lot sizes, steep roofs, and constructed prior to energy codes. The variations between the two archetypes, for this

date range, were in the complexity of the building form and architectural style. Complex forms were associated with architectural styles such Queen Anne, Stick, and Folk Victorian styles. Block forms were associated with styles and forms such as Greek Revival, Italianate, and Four Square. Complex forms typically included a number of features such as complicated roof shapes, extensive dormers, multiple gables, turrets and other similar features that increase the wall surface to floor area ratio or otherwise create complicated conditions for insulating, air sealing, and BEopt modeling. The research team observed almost no examples of homes during this time period that were outside of the two archetypes. These archetypes are identified as 1 and 2 in Table 16 of Section 4. These two archetypes represent 14.7% (approximately 7,000) of the Ann Arbor housing stock. The "Old West Side Charmers" (Old West Side Association, 2012) are included in these two archetypes and are shown in Table 10.

1950s–1960s era ranches also make up an important archetype. These are common in the Southwest Quadrant. Although this time period has more overall variation than the period before 1930, the ranch archetype is well defined and makes up more than half of the homes from this period. Approximately 43% of Ann Arbor's housing was constructed between 1940 and 1969, reflecting close to 20,000 homes of which the CEER team estimates that more than 8,000 one-story ranches were constructed during this time frame. These homes were universally one story with basements, platform framed, and had low slope roofs. Although many homes in the Zillow listings indicated some upgrades, the listings rarely indicated any energy-related upgrades. While there were instances where window, furnace, or air conditioning was identified as an improvement in the listings, these accounted for only a small fraction of the listings. Instead, upgrades were generally listed as kitchen upgrades, bathroom replacements, countertops, and so forth. The number of one-story ranches from this time period, along with construction systems of the time, and with few instances of energy upgrade led the CEER team to identify this archetype as significant for energy retrofit research for the Ann Arbor area.

Table 10 shows representative examples of the three most common archetypes found in Ann Arbor that were all built before higher energy codes were enacted. Detailed information about exterior materials and foundation is presented below.

Table 10. Examples of Prevalent Housing Archetypes in Ann Arbor

Archetype	Ranch	Charmer—Greek Revival Style	Charmer—Vernacular Front Gable
Built	After 1950	Before 1930	Before 1930
Story	1	2	2
Exterior Material	Brick, or vinyl siding	Aluminum shingle, vinyl siding, wooden clapboard or asbestos siding	Aluminum siding, vinyl siding, or asbestos shingle
Roof Material	Asphalt shingle	Asphalt shingle	Asphalt shingle
Windows	Not upgraded	Not upgraded	Not upgraded
Interior Wall Insulation	Occasionally	Rarely	Rarely
Attic Insulation	Occasionally	Rarely	Rarely
Housing	Block form	Block form	Block form

Archetype	Ranch	Charmer—Greek Revival Style	Charmer—Vernacular Front Gable
Form			
Foundation Material	Usually unexposed	Stone or stucco	Stone, exposed concrete blocks, or stucco
Examples			

Note 1: All data are available in Appendix B.
Note 2: All photo images were taken by A. Harrell-Seyburn and N. Ehrlich.

3.3.2.7 Conclusions—Ann Arbor

The Ann Arbor analysis led to the identification of three prevalent archetypes that are distinct and important for the Ann Arbor market. These included two multistory archetypes from before 1930, and one-story ranches constructed during the 1950s–1969. The statistical analysis conducted from the AHS identified prevalent home types based on number of houses and energy consumption. There is some variation for the United States and the Midwest region when compared to Ann Arbor.

Table 11 below shows prevalent archetypes from the national and Midwest statistical analyses, as well as prevalent archetypes in Ann Arbor. The most reasonable targets for energy-efficient retrofit are houses built before 1949 that have two stories and have vertically oriented block forms (referred to as "Charmers" in this study) and one-story ranch homes with basements built between 1950 and 1979 and can be defined as the simple block form.

Table 11. Prevalent Housing Archetypes That Need More Energy Efficiency

Findings From:	2009 AHS			Ann Arbor Case study		
	In the Midwest	Major type1 out of 36 types	Major type 2 out of 36 types	Charmers		Ranches
Form				Block	Complex	Block
Style	Information unavailable	Information unavailable	Information unavailable	Greek Revival, Colonial Revival, or Vernacular	Queen Ann, Sticks, or Folk Victorian	Ranch
Year the House Built	Before 1930 Between 1950–1960	1930–1949	1970–2009	Before 1930		After 1950s
Square Footage	> 2,500	900–2,500	> 2,500	900–2,500		900–2,500
Story	3 or higher	3 or higher	3 or higher	2 or higher		1
Other Features	With a fireplace With a basement With air conditioning	With a fireplace With a basement With air conditioning	With a fireplace With a basement With air conditioning	Siding: Aluminum siding, asbestos shingle, or vinyl siding Roof: Asphalt shingle Foundation: Exposed concrete blocks or stucco		Siding: vinyl siding, or bricks Roof: Asphalt single Foundation: Exposed concrete blocks or stucco

Through this case study the CEER team found Zillow to be an effective way to quickly view a local market and understand its housing stock. Use of Zillow along with corroborating information from the census, local housing experts, public documents, and site visits was a relatively quick and effective way to understand the local housing stock for application of the housing taxonomy. Furthermore, it was possible to gain an understanding of the types of upgrades that owner sellers had made to their houses. The vast majority of improvements were cosmetic, or functional such as bathroom or kitchen remodeling. Only a few energy efficiency upgrades were mentioned, and were typically air conditioning upgrades or furnace upgrades, and almost never general energy retrofit upgrades.

3.4 Local Market Characterization Framework

The CEER team identified effective sources of information for characterizing a local market during the Ann Arbor study. Process steps for a case study to determine prevalent archetypes were discussed in Section 3.3.2. At the conclusion of the case study a framework for collecting data was developed and is shown in Figure 9.

Process	Objectives	Data Collection Methods	Data Sources
Review literature	To explore literature on energy retrofit research and on housing taxonomies and demographics	Literature review	BA Research resources and reports, general research literature, and data from the U.S. Census Bureau
Research housing styles	To identify housing styles in the United Sates and Michigan	Literature review	Literature: A Field Guide to American Houses by McAlester and McAlester 1984.
	To identify housing styles available in Michigan and the Great Lakes sub-region	Expert meetings	Two architectural historians in the State Historic Preservation Office
Analyze general housing market for energy-efficient retrofit	To identify the general characteristics of the housing market in the nation and the targeted areas	Housing data review and analysis	American Fact Finder AHS
Analyze a local housing market	To estimate the total number of houses falling on the prevalent archetypes	Statistical analysis	The number of entire houses in the city
	To understand geographical and socioeconomic growth of the city	Map review	Google Earth maps, Sanborn maps
Meet with local industry experts and government officials specialized in housing	To investigate local housing market and prevalent housing (arche)types for energy-efficient retrofit	Informational meeting	Meeting contents
Visit sites and observe neighborhoods and houses	To quantify the number of houses in the prevalent archetypes in the targeted area	Observations with a local map and a checklist	Actual number of housing reflecting the physical characteristics of the prevalent archetype
Review and analyze archival documents	To confirm major housing archetypes for the targeted city	Descriptive analysis	Intensive Housing Survey Report by the State Historic Preservation Office
Prevalent Housing Archetypes in a Local Market Identified			

Figure 9. Framework to determine prevalent archetypes

3.5   Case Study in Grand Rapids, Michigan
3.5.1   Case Study—Grand Rapids

The CEER team conducted a second case study of Grand Rapids. The primary purposes of the Grand Rapids study were to identify prevalent housing archetypes for future energy-efficient retrofit research and to utilize the characterization framework in a different local market in order to test its application. The Grand Rapids study followed the framework constructed during the Ann Arbor study with some variations based on information available.

3.5.2   The City of Grand Rapids Historical Context

Grand Rapids was settled in the 19th century and it was incorporated as a village in 1838 and as a city in 1850. By 1900 it had a population of 90,000 (Samuelson and Schrier 2003). Housing in Grand Rapids was primarily in the city core until after World War II, when Grand Rapids experienced rapid growth. Inexpensive housing, on a massive scale, created commuter neighborhoods outside the city limits and led to a population shift (Lewis 2008).

Figure 20 shows the growth and development eras for Grand Rapids along with CEER neighborhood site visit locations. The city's core downtown area is occupied largely by pre-1940 homes, while the outlying areas have many 1960s ranches and modern homes.
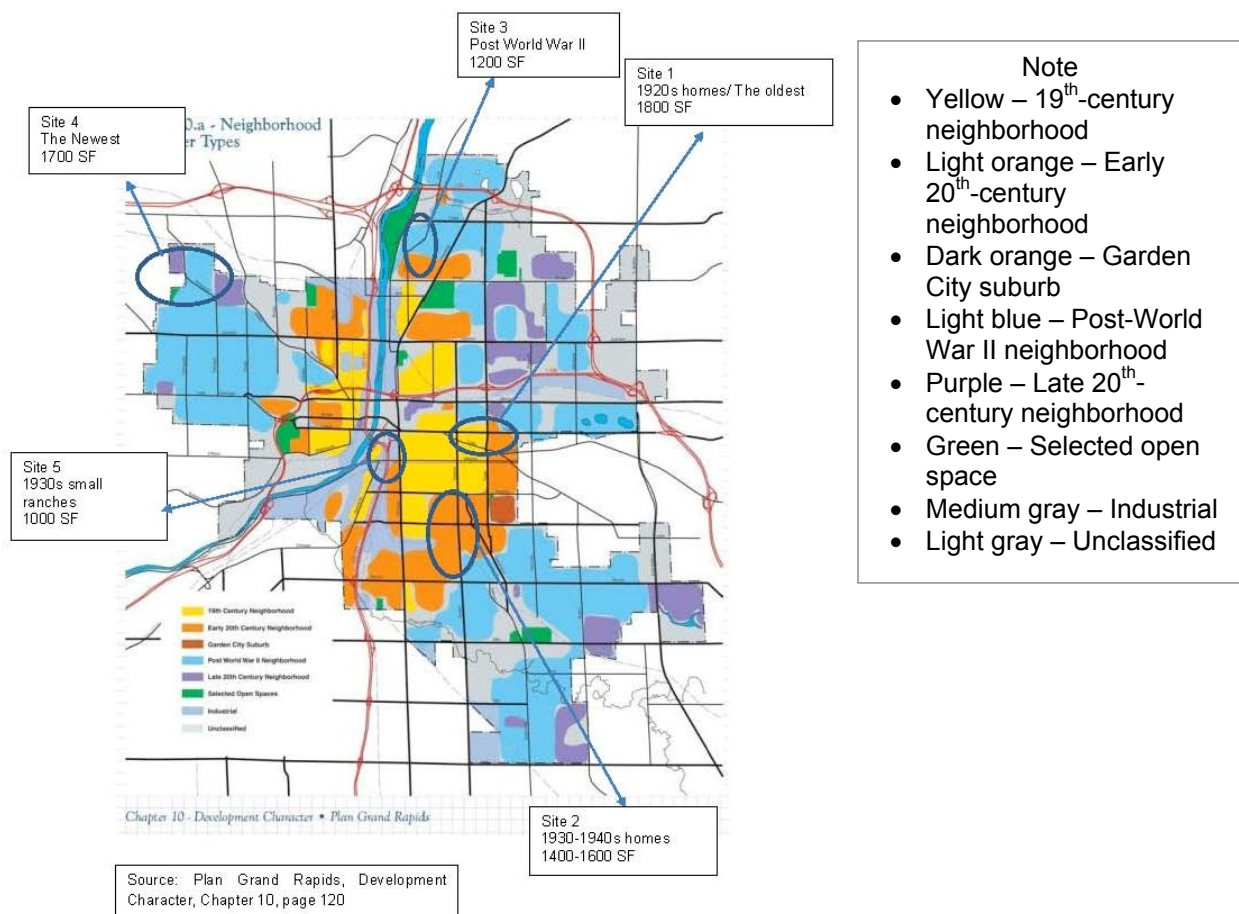
Figure 10. City of Grand Rapids and neighborhoods for CEER site visits in Grand Rapids

(Source: City of Grand Rapids (2012). Plan Grand Rapids, p. 120)

Grand Rapids housing stock included 81,595 units, which accounts for 1.79% of existing Michigan housing (U.S. Census Bureau 2010). The housing stock was slightly older than that of Ann Arbor and Michigan as a whole. Table 7 from Section 3.3.1 showed that 96.1% of Grand Rapids housing was built before 2000. Michigan adopted its first energy code in 1999; consequently, most of the housing stock was built without energy codes. Table 7 also shows that 38.9% of the housing stock was built before 1940.

3.5.2.1 Meetings With Local Housing Experts
Meetings were held with Grand Rapids housing officials to identify available information, identify city boundaries, to gain an understanding of city growth patterns and housing stock and to determine characteristic neighborhoods for site visits. During these meetings five target neighborhoods were identified as candidate site visit neighborhoods. Several key planning documents were made available to the project team.

3.5.2.2 Review of Public Information
Similar to the Ann Arbor study, the CEER team reviewed public information for Grand Rapids, including census documents and a development plan report furnished by the City of Grand Rapids (http://grcity.us/Pages/default.aspx). Additional sources reviewed were Sanborn Fire Maps and Google Earth images, which were used to gain a perspective on growth patterns and the organization of neighborhoods. Information from these sources provided the background for Section 3.5.2.1.

3.5.2.3 Site Visits
Neighborhood visits were conducted of five neighborhoods in order to match the housing taxonomy described in Section 3.2 to the Grand Rapids existing housing stock. Generally, 30–40 houses were observed within each neighborhood. The five neighborhoods were selected based on meetings with city housing officials who worked with community development and energy-efficient housing programs and were built in varying eras and had unique characteristics. Site 1 included numerous homes built during the 1920s that ranged in sizes typically > 1,800 ft². Site 2 was developed between the 1930s and 1940s. Site 3 had numerous post-World War II homes that typically ranged around 1,200 ft². Site 4 was the newest neighborhood among the five target neighborhoods, and included a number of ranch style homes. Site 5 was built in the 1950s and included a number of ranch style homes < 1,200 ft². To document the site visits the research team developed visual profiles of each neighborhood. Excerpted below is an example of Site 1, which is bounded by Hope and Fuller Streets and consists of 1920s homes typically > 1,800 ft². This is the oldest neighborhood among the five subject sites. Many homes showed Craftsman, Greek Revival, or Gothic Revival styles. A majority of the homes had asphalt shingle roofs and painted wood exteriors or replacement vinyl. Virtually all homes included basements that were constructed of concrete block, with some instances of stone. Most homes were two-story homes, but some were three stories. (See Figure 11 below.)

Figure 11. Site 1—neighborhood view

(Source: http://map.google.com [left above map]. All photos by S.-K. Kim)

3.5.2.4 Analysis of Current Housing Stock Through Real Estate Sources

The CEER team searched www.zillow.com to examine properties which are currently for sale, recently sold, and for rent and again reviewed individual property listings and photo sets to apply the housing taxonomy presented in Section 3.2 and to help identify common archetypes for Grand Rapids.

Similar to the Ann Arbor case study, the CEER team correlated the Zillow dataset with census data to determine if the Zillow listings would be an approximate match to the housing distribution by year built from the census data.

Zillow listed close to 11,000 properties for Grand Rapids, representing about 13% of the entire housing stock. The Zillow search yielded 9,308 "recently sold," 1,307 "for sale," and 369 "rental" homes in Grand Rapids on June 2012 (see Table 12).

Table 12. Distribution of Recently Sold Homes Grand Rapids

Construction Eras	Zillow Data		Zillow Data Subtotals	Census Grand Rapids	
1800–1899	556	7.6%			
1900–1910	936	12.7%			
1911–1920	256	3.5%	43.9%	Before 1939	38.9%
1920–1929	1303	17.8%			
1930–1939	172	2.3%			
1940–1949	630	8.6%			
1950–1959	1959	26.8%	42.1%	1940–1969	36.4%
1960–1969	482	6.7%			
1970–1979	298	4%			
1980–1989	196	2.7%	9.9%	1970–1999	20.8%
1990–1999	231	3.2%			
2000–2012	279	3.8%	3.8%	2000–2012	3.9%
Total	7,298*	100%	100%	Total	100.0%

(Source: www.zillow.com)

NOTE: *Not all homes had dates so the total of searches by decade is fewer than the total number of homes (9,308 in the entire data listing set).

The CEER team again matched the distribution of housing stock identified by Zillow.com by decade to the Census Bureau data and found there was an approximate match between the Zillow-filtered searches and the distribution of homes by decade built from the census data (reported in Section 3.3.1).

Table 12 shows Zillow data for homes built before 1939 as 43.9% of the dataset, while census data show 39% for this date range. Zillow data show 42.1% of the dataset for the period 1940–1969, while the census data show 36.3%. There was some variation in homes for the periods 1970–1999 and 2000–2012, with Zillow showing 9.9% and 3.8% for these periods and the census data showing 21.2% and 3.9%. Appendix E shows analysis from analysis from Zillow.com.

3.5.2.5 Analysis

The census data showed that the housing stock in Grand Rapids is older than that of Michigan as a whole. Approximately 38.9% of the housing stock was built before 1940, and 36.4% built during 1940–1969. The combined analysis of the census data, Zillow.com, planning reports, and the neighborhood site visits showed that ranch style one-story homes are generally 1,000–1,200 ft^2 and built from 1940–1969. Examples are shown in Figure 12 through Figure 14.

Ranch style homes were mainly built after 1950. Common materials found are asphalt shingled roofs; brick, aluminum, or combinations of siding were common for exterior walls, and most homes had concrete block basements. Ranch style homes built in the 1950s typically were built with uninsulated walls, minimal roof insulation, single-glazed windows, and uninsulated basements.

The period of the 1930s through the 1950s and early 1960s also saw the development of 1½-story homes in Grand Rapids with finished bedroom spaces and other living spaces above the

first floor. Common examples are Cape Cod style homes with typically two to three bedrooms and possibly one or one and a half bathroom located within the roof form and above the first floor. Dormers were common. These 1½-story homes present some unique energy retrofit challenges because they frequently have partially sloped raftered ceilings with finish materials applied to the underside of the rafters, as well as knee walls. These conditions make adding insulation above the ceiling somewhat more difficult to accommodate than when an attic is available.

Two-story homes are 1,400–1,600 ft^2 and built before 1940 and are more prevalent than other housing types. Two-story homes were commonly of Greek Revival, Craftsman (American Four Square), or vernacular styles and were more prevalent than other styles having similar roof, siding, and foundation materials. Many of these homes were balloon framed and had block building forms and steep roofs (see Figure 12 through Figure 17).

Figure 12. Ranch built in the 1950s

Figure 13. Ranch built after the 1960s

Figure 14. Ranch built after the 1960s

Figure 15. Two-story house built in the 1910s

Figure 16. Two-story house built in the 1930s

Figure 17. Two-story house built in the 1930s

All photos by S.-K. Kim

3.5.2.6 Conclusions—Grand Rapids

The case study in Grand Rapids was conducted in order to identify prevalent archetypes for future energy retrofit research. The study showed that the housing stock was older than that of Michigan and that of the Midwest in general. It also showed that the house mix is closely tied to business and economic conditions of various eras. Ranch style homes of 1,000–1,200 ft^2 and two-story homes of 1,400–1,600 ft^2 are more prevalent than other housing types. Ranch style homes were mainly built after 1950. Common materials found include asphalt shingle roofs, aluminum siding on exterior walls, and concrete block foundations. Two-story houses in Grand

Rapids can be categorized into two groups depending on construction era: prior to 1910s and 1930s to 1940s. Figure 12 through Figure 17 show the prevalent archetypes.

Additionally, 1½-story homes began to emerge in the early 1930s in the Grand Rapids market and continued into the 1950s. While this archetype is likely smaller in total numbers in Grand Rapids, it represents a common archetype with particular roof insulating challenges and exists in high numbers in the Midwest.

3.6   Review of the Characterization Framework

A framework for characterizing local markets was developed as a result of the Ann Arbor case study. This framework was then used to collect data and characterize the Grand Rapids housing market. Applying the framework allowed the CEER team to characterize high priority homes for energy retrofit research in Grand Rapids, but also can serve as a guide approach for other BA teams and for local energy retrofit program managers and retrofit contractors.

While the Ann Arbor process was closely followed, some additional informational sources were used in the Grand Rapids study, including the use of Google Earth to be able to quickly assess homes in a neighborhood. Roof shape many times is a defining characteristic of homes and can be used to locate similar homes within a neighborhood. For example, in the Black Hills Neighborhood of Grand Rapids Google Earth showed more than 50 homes that closely matched the archetype within the closely defined neighborhood. A ground survey of the neighborhood found no variation from the determination of homes likely to be within the archetype from the aerial views. Additionally, the CEER team reviewed Sanborn Fire Maps. These maps were useful for understanding growth trends within the city, but were difficult to obtain, cumbersome to use, and were not as useful in characterizing individual homes.

The process of data collection methods used for the case study in Ann Arbor and Grand Rapids are summarized in Table 13.

Table 13. Summary of Research Activities and the Process of Case Studies in Ann Arbor and Grand Rapids

Proposed Framework	Ann Arbor Case Study	Grand Rapids Case Study
Review Literature	Review BA reports and relevant publications	Review BA reports and relevant publications
Research Housing Styles — Statistical Analysis and Expert Meetings	Analyze housing styles and create astyle taxonomy, based on literature review and expert meetings	The housing taxonomy created applied in this local market
Analyze General Housing Market for Energy-Efficient Retrofit	Analyze American Community Survey and AHS	The content analyzed for the Ann Arbor study applied in this case study
Analyze a Local Housing Market — Statistical Analysis and Map Review	Analyze local housing data obtained from Zillow.com SEMCOG* and Sanborn fire maps and Google Earth	Analyze local housing data obtained from Zillow.com and Sanborn fire maps and Google Earth
Meet with Local Housing Experts and Governmental Officials Specialized in Housing	Meet with two local industry experts with more than 20 year experience	Meet with two governmental officials specialized in housing
Visit Sites and Observe Neighborhoods and Houses	Visit three neighborhoods built developed during different eras, observe houses, and identify characteristics	Visit five neighborhoods developed during different eras, observe houses, and identify characteristics
Review and Analyze Archival Documents	Analyze the Housing Intensive Survey Report authored by the Michigan Historic Preservation Office	Analyze city archives (www.grcity.us) and the other energy-efficient housing program
Select the most frequently found and representative housing types in the targeted local market		

Note: SEMCOG: Southeast Michigan Council of Governments

4 Conclusions

The purpose of this market characterization project was to identify housing archetypes that are prevalent within the Great Lakes region and therefore offer significant potential for research and implementation due to the substantial number of homes possessing similar characteristics.

Effective energy-retrofit solutions should vary by housing characteristic such as style, construction type, materials, configuration, existing construction details, building form, and number of stories, due to variations in access for insulating, air sealing, and installing new ductwork (Hendron and Engebrecht 2006). Furthermore, many of these characteristics are common to certain housing archetypes that frequently occur and can be grouped by vintage and building form, and occur in sufficient numbers within a region.

Understanding the characteristics of housing groups can allow research teams to focus their retrofit research and develop prescriptive solutions for those structure types that are prevalent and offer suggestions for high potential uptake within a region or market.

This project developed a framework for identifying prevalent housing archetypes in a local market based on a holistic analytical approach that integrated both quantitative and qualitative approaches. This framework is expected to be applicable in any local market in the Great Lakes sub-regions.

The primary objectives of this project and major findings were as follows:

Objective 1. Characterize the existing housing stock in the Great Lakes region.

To accomplish this goal, the CEER team analyzed housing data covering the Great Lakes region such as 2009 AHS and 2006-2010 America Community Survey provided by the U.S. Census Bureau (2009 and 2010), and created taxonomies of housing styles for the United States and specifically Michigan based on literature and meetings with architectural style experts.

There are several highlights from the results.

First, the 2006–2010 American Community Survey 5-Year Estimates showed the highest percentage of homes built in the Great Lakes region were built before 1930. These homes were categorized according to construction eras

Figure 18. Construction eras of current U.S. housing stock

(Graph created by S.-K. Kim)

(or vintage). The next highest percentages were from homes built during the 1970s and 1950s. Energy codes were established in the late 1990s and consequently, the majority of housing in the Great Lakes region lack modern energy-efficient features since they were built prior to the 1970s and have undergone only limited upgrades (Figure 18).

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The 2009 AHS analysis led to identification of 36 housing types based on vintage, size, and number of stories. These housing types were then correlated with MEB data from AHS to identify high impact types based and quantity of homes and MEBs. The most common and energy consumptive housing types based on MEB in the Midwest were three or more story houses, 2,500 ft^2 or larger built since 1970 (8.04%), and three or more story houses, 900–2,500 ft^2 built between 1930 and 1949 (4.19%). This classification includes a broad range of dominant housing styles in the target region.

The CEER team concluded that house size, number of stories, the year the house was built, air conditioning, basement, and attached garage or carport can be influential architectural variables in determining dominant archetypes for energy-efficient retrofit, according to the statistical models the team obtained based on the AHS data analysis.

Concurrent with the statistical study, a style library was developed and prevalent architectural styles in the Midwest were identified. The style library was used to help describe common archetypes shown in Table 16. Common styles included Greek Revival, Gothic Revival, and Italianate built between the 1820s and 1880s; Stick, Queen Anne, and Folk Victorian between the 1860s and the 1900s; Colonial Revival, Neoclassical, Tudor, Craftsman, and Tudor Revival between the 1880s and the 1940s; and Ranch, Split-Level, Neoclassical Revival, and Neo-Victorian since 1940s.

Objective 2. Conduct market characterization case studies of two cities in the Great Lakes region.

The intensive case studies targeted the cities of Ann Arbor and Grand Rapids, Michigan. From the 2009 AHS analysis, the architectural style review, and meetings with housing experts in these cities, the CEER team concluded the prevalent housing types (archetypes) for future energy-efficient retrofit research and implementation in Ann Arbor were two-story houses built before 1930 and one-story ranches built after 1950.

Table 14 summarizes prevalent archetypes that would benefit from energy efficiency upgrades and research based on prevalence in the local market.

The case study in Grand Rapids was conducted in order to identify prevalent archetypes for future energy retrofit research. The framework developed from the case study in Ann Arbor was used as a guide for the Grand Rapids study. This framework was useful and successfully implemented in the case study in Grand Rapids. Process steps were documented.

The case study in Grand Rapids showed that the housing stock was older than that of Michigan and that of the Midwest in general. It also showed that the house mix is closely tied to business and economic conditions of various eras. Ranch style homes of 1,000–1,200 ft^2 and two-story homes of 1,400–1,600 ft^2 are more prevalent than other housing types. Ranch style homes were mainly built after 1950. Common materials and assemblies in the homes include asphalt shingle roofs, aluminum siding on exterior walls, uninsulated concrete block foundations, single-glazed windows, un-insulated walls unless there has been a subsequent upgrade and minimal roof insulation. Two-story houses in Grand Rapids can be categorized into two groups depending on construction era: prior to the 1910s and the 1930s to the 1940s.

Table 14. Prevalent Housing Archetypes That Need More Energy Efficiency

Findings From:	AHS			Ann Arbor Case study		
	In the Midwest	Major type1 out of 36 types	Major type2 out of 36 types	Charmers		Ranches
Form				Block	Complex	Block
Style	Information unavailable	Information unavailable	Information unavailable	Greek Revival, Colonial Revival, or Vernacular	Queen Anne, Sticks, or Folk Victorian	Ranch
Year the House Built	Before 1930 Between 1950–1960	1930–1949	1970–2009	Before 1930		After 1950s
Square Footage	> 2,500	900–2,500	> 2,500	900–2,500		900–2,500
Story	3 or higher	3 or higher	3 or higher	2 or higher		1
Other features	With a fireplace With a basement With air conditioning	With a fireplace With a basement With air conditioning	With a fireplace With a basement With air conditioning	Siding: Aluminum siding, asbestos shingle, or vinyl siding Roof: Asphalt shingle Foundation: Exposed concrete blocks or stucco		Siding: vinyl siding, or Bricks Roof: Asphalt single Foundation: Exposed concrete blocks or stucco

Figure 12 through Figure 17 in Section 3.5.2.5 showed prevalent archetypes that would benefit from energy efficiency upgrades and should be targeted for energy retrofit research in Grand Rapids. The homes are highly representative of the BA retrofit benchmark criteria in BEopt. The study also showed that 1½-story homes such as Cape Cod homes constructed starting in the 1930s through the 1960s would also benefit from energy retrofit research, since they have particular retrofit insulating challenges and occur across the Midwest.

Objective 3. Establish a protocol that can be used by other researchers, policy makers, energy retrofit programs, and energy retrofit companies to effectively channel their activities to prevalent archetypes in their regions or markets.

This research developed the following framework for determining prevalent housing archetypes in a local market based on empirical case studies (see Table 15).

Table 15. Proposed Framework for Future Implementation

Framework	Objectives	Data Collection Methods	Data Sources
Review Literature	To explore literature on energy retrofit research and on housing taxonomies and demographics	Literature review	BA Research resources and reports, general research literature, and data from the U.S. Census Bureau
Research Housing Styles — Statistical Analysis and Expert Meetings	To identify housing styles in the United States and Michigan	Literature review	Literature: A Field Guide to American Houses by Virginia and Lee McAlester. 1984.
Analyze General Housing Market for Energy-Efficient Retrofit	To identify housing styles available in Michigan and the Great Lakes sub-region	Expert meetings	Two architectural historians in the State Historic Preservation Office
Analyze a Local Housing Market — Statistical Analysis and Map Review	To identify the general characteristics of the housing market in the nation and the targeted areas	Housing data review and analysis	American Community Survey AHS
Meet with Local Housing Experts and Governmental Officials Specialized in Housing	To estimate the total number of houses falling in the prevalent archetypes	Statistical analysis	The number of entire houses in the city
	To understand the geographical and socioeconomic growth of the city	Map review	Google Earth maps, Sanborn maps
Visit Sites and Observe Neighborhoods and Houses	To investigate the local housing market and prevalent housing (arche)types for energy-efficient retrofit	Informational meeting	Meeting contents
Review and Analyze Archival Documents	To quantify the number of houses in the prevalent archetypes in the targeted area	Observations with a local map and a checklist	Actual number of housing reflecting the physical characteristics of the prevalent archetype
	To confirm major housing archetypes for the targeted city	Descriptive analysis	Intensive Housing Survey Report by the State Historic Preservation Office

Objective 4. Establish criteria for selecting high impact case studies with the largest potential for implementation/leveraging to a larger set of homes.

Table 16 shows characteristic of homes and their criteria for classification into archetypes. Criteria for selection of archetypes for energy retrofit research include vintage, which correlates with construction systems and materials; prevalence; MEBs; and building form.

Table 16. Characteristics for Selecting Prevalent Housing Archetypes

ID	Date Range	Frame		Form		Story		Orientation		Base	Roof		Code	Style Remarks
		Balloon Frame	Platform Frame	Block Form	Complex From	Multiple Stories	Single Story	Vertical Orientation	Horizontal Orientation	Basement	Steep Roof Slope + Attic	Shallow roof pitch	Energy Code in Place	
1	Before 1930	•			•	•		•		•	•			Vernacular Queen Anne Gothic Revival Stick Queen Anne Folk Victorian
2	Before 1930	•		•		•		•		•		•		Greek Revival Italianate Four Square
3	1930-1949		•	•		•		•		•		•		Colonial Revival Neoclassical Vernacular
4	1930-1949		•	•		•		•		•		•		1.5 Stories: Cape Cod Bungalow Craftsman Neoclassical
5	1930-1949		•		•	•		•		•	•			Tudor Tudor Revival Craftsman Other
6	1930-1949		•	•			•		•					Ranch
7	1950-1969		•	•		•		•		•				Neoclassical Neocolonial Modern
8	1950-1969		•		•	•		•	•	•				Split-Level 1½ Story Cape Cod
9	1950-1969		•	•			•		•	•				Ranch
10	1970-1979		•	•		•			•	•				Traditional references
11	1970-1979		•		•	•			•	•				Traditional references

ID	Date Range	Balloon Frame	Platform Frame	Block Form	Complex From	Multiple Stories	Single Story	Vertical Orientation	Horizontal Orientation	Basement	Steep Roof Slope + Attic	Shallow roof pitch	Energy Code in Place	Style Remarks
12	1970-1979		●	●			●		●	●				Traditional references
13	1980-1999		●			●				●				Traditional references
14	1980-1999		●			●				●				Traditional references
15	1980-1999		●				●			●				Traditional references
16	2000-2012		●	●			●		●	●			●	1 story
17	2000-2012		●	●		●			●	●			●	2 Story
18	2000-2012		●		●	●			●	●			●	2 Story

Table 16 above highlights four archetypes recommended for BA research in our region and includes pre-1930 multistory block form homes identified as ID 1 in the table, 1½-story homes such as Cape Cod homes from 1930 to 1960 (ID 4), one-story ranch homes from 1950–1969 (ID 9) and multistory homes typical of homes built in suburbia during the 1970s (ID 11).

The research found that national and regional survey data are useful for identifying housing trends and characteristics at a high level. However, local housing stock characteristics will vary from the patterns of national and regional data. Therefore, observing the housing stock within a local or even a statewide market can help provide a refined and focused understanding of the nuances of the housing stock that can lead to focused energy retrofit research.

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http://www.antiquehome.org

http://www.detroithomemag.com

http://www. 45thparallelrealty.net

http://www.ineedaninspector.com

http://www.oldhouses.com

http://www.zillow.com

Appendix A: Relevant Publications

Table 17 shows the research publications relevant to energy-efficient retrofit.

Table 17. A Summary of Research Publications Relevant to Energy-Efficient Retrofit

Year	Authors	Title	Subject Homes			Simulation Programs Used	Other Notes
			Climate Zone	No. of Subject Homes	Any Types of Homes Used for Simulations		
2012	Parker and Sherwin	Achieving Very High Efficiency and Net Zero Energy in an Existing Home in a Hot-Humid Climate: Long-Term Utility and Preliminary Monitoring Data	Zone 2 (Florida)	1	1,800-ft^2 one-story rectangular single family house with 200-ft^2 attached garage and 300-ft^2 enclosed south room	Energy Gauge USA, Building Energy Simulation	Blower door fan-pressurization tests and sulfur hexafluoride (SF6) tracer gas tests were used to determine the house air infiltration characteristics
2012	Burdick	Strategy Guideline: HVAC Equipment Sizing	Zone 2 (Orland) and Zone 5 (Chicago)	2	Chicago House is a house over a full basement, the Orlando House is a slab-on-grade foundation	None indicated	
2012	Spanier et al.	Chicagoland Single-Family Housing Characterization	Zone 5 (Chicago, Cook County)	464,745	15 groups of homes based on architectural features	BEopt	Testing current homes' energy-efficiency and proposing future energy-efficiency upgrading for 15 groups
2012	No specific indicated	National Residential Efficiency Measures Database Aimed at Reducing Risk for Residential Retrofit Industry	None indicated	None indicated	None indicated	None indicated	
2011	Taggart et al.	Strategy Guideline: Quality Management in Existing Homes - Cantilever Floor Example	Zone 4 (Washington D.C.)	1	Two-story house	None indicated	Performance testing/home energy rater and post-blower door test
2011	Gates and Osser	Reaching for Peak Performance in Existing Homes – A Cold Climate Study With Synergy Construction	Zone 5 (Massachusetts)	2	Test Home 8.1a ("Millbury Cape") Cod-style house built in the 1950s and The 8.1b Test Home ("Somerville	BEopt Energy modeling	Blower door testing was performed for both to gauge the success of air sealing efforts. Utility bills from before and after the retrofits were collected from

Year	Authors	Title	Subject Homes				Other Notes
			Climate Zone	No. of Subject Homes	Any Types of Homes Used for Simulations	Simulation Programs Used	
					Triple Decker") is a triple decker multifamily wood-framed building typical of New England, circa 1920.		home occupants to compare measured fuel usage, showing clear reductions in post-retrofit energy use. These utility bill summations are compared to the results of BEopt energy modeling, to show incremental energy reduction from each retrofit measure.
2011a	Bianchi	Technical Barriers, Gaps, and Opportunities Related to Home Energy Upgrade Market Delivery	Not indicated	None indicated	None indicated	None indicated	
2011	Maguire et al.	Condensing Hybrid Water Heater Monitoring Field Evaluation	Zone 3 (Sacramento, CA)	1	One-story ranch built in 1950s	None indicated	Field monitoring was performed to determine the in-use efficiency of the hybrid gas condensing water heater (Navien CR240-A) installed at the home. These results were then compared to the unit's rated efficiency.
2011	Pacific Northwest National Laboratory and Oak Ridge National Laboratory	Building America Best Practices Series Volume 14 - HVAC: A Guide for Contractors to Share with Homeowners	None indicated	None indicated	None indicated	None indicated	
2011b	Bianchi	Challenges and Opportunities To Achieve 50% Energy Savings in Homes: National Laboratory White Papers	None indicated	None indicated	None indicated	None indicated	
2011	Burdick	Strategy Guideline: Accurate Heating and Cooling Load Calculations	Zone 2 (Orland) and Zone 5 (Chicago)	2	None indicated	None indicated	

Year	Authors	Title	Subject Homes				Other Notes
			Climate Zone	**No. of Subject Homes**	**Any Types of Homes Used for Simulations**	**Simulation Programs Used**	
2011	Polly et al.	A Method for Determining Optimal Residential Energy Efficiency Packages	see the note	8	1,280 ft2 ranches and are identical except for a climate appropriate foundation, the location of the ductwork, shingle solar reflectance, and exterior finish	BEopt Energy modeling	Zone 2 (Houston, TX and Phoenix, AZ), Zone 3 (Atlanta, GA and San Diego, CA), Zone 4 (Seattle, WA and Washington D.C.), Zone 5 (Chicago, IL), Zone 6 (Minneapolis, MN)
2010	Cummings et al.	Evaluation of Bias Issues within Regression-Based Inverse Modeling Methods Against Climate and Building Characteristics Using Synthetic Data	Zone 2 (Northport, FL)	30 homes total: 2 Specific homes described in study	1,446-ft^2, one-story home (Florida) and 1824-ft^2. (Atlanta)	Unspecified energy simulation software	Each size house was simulated with one story and two stories. To change the home to two stories, researchers doubled the first floor area while keeping the length-width ratio of the house and the window area the same.
No info	No specific indicated	ReVision Home: Energy Modeling	Not indicated	1	House with uninsulated slab-on-grade foundation	Unspecified energy simulation software	
No info	No specific indicated	ReVision Home: Weatherization Products	Zone 3 (Las Vegas, NV)	1	None indicated	None indicated	
2010	Pacific Northwest National Laboratory and Oak Ridge National Laboratory	High-Performance Home Technologies: Guide to Determining Climate Regions by County-Volume 7.	see the note	None indicated	None indicated	None indicated	This guide describes the climate zone designations used by Building America and compares then with the climate zone designations used in the IECC.
2010a	Judkoff et al.	Building Energy Simulation Test for Existing Homes (BESTEST-EX); Phase 1 Test Procedure: Building Thermal Fabric Cases	Zone 3 (Las Vegas, NV and Colorado Springs, CO)	None indicated	None indicated	BESTEST-EX	
2010b	Judkoff et al.	Example Procedures for Developing Acceptance-Range	None indicated	None indicated	None indicated	BESTEST-EX	

Year	Authors	Title	Subject Homes				Other Notes
			Climate Zone	No. of Subject Homes	Any Types of Homes Used for Simulations	Simulation Programs Used	
		Criteria for BESTEST-EX					
2006	Hendron and Engebrecht	Building America Performance Analysis Procedures for Existing Homes	None indicated	None indicated	None indicated	None indicated	
2004	Drumheller and Wiehagen	Strategies for Energy-Efficient Remodeling: SEER 2003 Case Study Report	New Jersey	2	Two homes and a barn: 1,400-ft^2 cottage house unoccupied for 10 years, and a 4,000-ft^2 home	None indicated	
2001b	Asthma Regional Coordinating Council of New England	Healthy and Affordable Housing: Practical Recommendations for Building, Renovating and Maintaining Housing: Read This Before You Turn Over a Unit	None indicated	None indicated	None indicated	None indicated	
2001a	Asthma Regional Coordinating Council of New England	Healthy and Affordable Housing: Practical Recommendations for Building, Renovating and Maintaining Housing: Read This Before You Move In	None indicated	None indicated	None indicated	None indicated	

Source: www1.eere.energy.gov/library/browsebytopic.aspx?page=2andspid=2

Appendix B: Initial Taxonomy

Table 18 shows the initial taxonomy that illustrates examples across the United States, which is described in Section 3.2.3.

Table 18. Architectural Styles of American Houses

Period	Source	Styles	Concentrating Areas of This Style
1600-1820 Colonial Houses	McAlester and McAlester (1984)	Postmedieval English Dutch Colonial French Colonial Spanish Colonial Georgian Colonial Adam Early Classical Revival	– Eastern Virginia and Pennsylvania, New York, Massachusetts – Near Albany, NY and along the Hudson River, NY (p. 114) – Scattered along the principal waterways, particularly in Great Lakes and Mississippi valleys (p. 122) – St. Augustine, Tucson, Santa Fe, San Diego etc., and a few rural communities in Texas and New Mexico (p. 132) – The east coast: Portsmouth, NH, New Port, RI, New Castle, DE, Annapolis, MD, New Bern, NC, etc. (p. 140) – The prosperous port cities of the east coast (p. 156) – Mainly concentrates in the southern states, particularly Virginia (p. 170)
	From other sources	New England Colonial German Colonial Federal and Adams	– Appeared from the 1500s. – New York, Pennsylvania, Ohio, and Maryland – Another name of Adam
1820–1880 Romantic Houses	McAlester and McAlester (1984)	Greek Revival Gothic Revival Italianate Exotic Revivals Octagon	– New York, Pennsylvania, Ohio, Illinois, Michigan, Virginia, Massachusetts, Wisconsin, Georgia, Texas, Kentucky, and Louisiana (p. 182)/ One of the most popular style – Northeastern states, where fashionable architects originally populated (p. 200) – Many cities of the Midwest (p. 212) – Egyptian, oriental, and Swiss Chalet included, very rare style (p. 231) – Very rare style, mostly built in New York, Massachusetts, and the Midwest (p. 235)
	From other sources	Call the above styles as "Classical Styles"	
1860–1900 Victorian Houses	McAlester and McAlester (1984)	Second Empire Stick Queen Anne Shingle Richardsonian–Romanesque Folk Victorian	– Northeastern and Midwestern states (p. 242) – Gabled examples popular in the northeastern states (p. 256) – Nationally prevalent style (p. 266) – Seaside resorts of the northeastern states: Newport, Cape Cod, eastern Long Island, and coastal Maine (p. 290) – Boston-based Henry Hobson Richardson designed houses Larger cities of the northeastern states (p. 302) – Common throughout the country (p. 310)
	From other sources	Eastlake House Victorian Sticks	– Actually Queen Anne houses – Another name of Stick style
1880–1940 Eclectic Houses	McAlester and McAlester (1984)	*Anglo-American, English, and French Period Houses* Colonial Revival Neoclassical Tudor Chateauesque	– Nationally prevalent style during the first half of 20th century. Nine principal subtypes distinguished (p. 324) – As popular as Colonial Revival in the similar period. Five principal subtypes distinguished (p. 343) – A prevalent style for a large portion of early 20th century. Six principal subtypes distinguished (p. 355) – A rare style used primarily for architect-designed houses. Most frequently found in the larger cities of the northeastern states (p .373)

Period	Source	Styles	Concentrating Areas of This Style
		Beaux Arts	– A style for architect-designed houses. Found in New York, Boston, Washington DC, St. Louis, and San Francisco. Two principal subtypes distinguished (p. 380)
		French Eclectic	– An uncommon style scattered throughout the nation (p. 388)
		Mediterranean Period Houses	– Found throughout the nation, but less common than Craftsman, Tudor, or Colonial Revival (p. 398)
		Italian Renaissance	– California (p. 409)
		Mission	– The southwestern states such as California, Arizona, Texas and Florida (p. 418)
		Spanish Eclectic	– Northern California (p. 431)
		Monterey	– California, Arizona, and Albuquerque and Santa Fe cities in New Mexico (p. 435)
		Pueblo Revival	
		Modern Houses	– Chicago, IL early 20th-century suburbs (i.e., Oak Park and River Forest), and other large Midwestern cities (p. 440)
		Prairie	– A prevalent style for smaller houses. Originated in southern California (p. 454)
		Craftsman	– Art Deco and Art moderne, scattered throughout the country (p. 465)
		Modernistic	– Occurred initially in suburbs in the northeastern states and California (p. 469)
		International	
	From other sources	Beaux Arts	– 1880–1929 Gilded Age
		Renaissance Revival	– 1880–1929 Gilded Age
		Tudor Revival	– 1880–1929 Gilded Age
		French Normandy	– 1890–1930 Neoclassical
		French Provincial	– 1890–1930 Neoclassical
		French Eclectic	– 1890–1930 Neoclassical
		Colonial Revival	– 1890–1930 Neoclassical
		Prairie Style	– 1901–1945 Early 20th Century
		Craftsman	– 1901–1945 Early 20th Century Craftsman includes Bungalow and American Four Square
		Art Moderne	– 1930–present Modernist
		Bauhaus	– 1930–present Modernist
		International	– 1930–present Modernist
Since 1940	McAlester and McAlester (1984)	Modern	– Modern includes Minimal Traditional, Ranch, Split-Level Ranch, Contemporary, and Shed, Found throughout the country (p. 477)
		Neoeclectic	– Neoeclectic includes Mansard, Neocolonial, Neo-French, Neo-Tudor, Neo-Mediterranean, Neoclassical Revival, and Neo-Victorian, Spread in the country (p. 487)
		Contemporary Folk	– Mobile Homes, Quonset Huts, A-Frames, and Geodesic Domes (p. 497)
	From other sources	Contemporary	– Categorized as Modernist Houses (1965–present)
		A-frame	– Categorized as Modernist Houses (1965–present)
		Neo-Colonial	– Categorized as Neo-Houses (1965–present)
		Neo-Mediterranean	– Categorized as Neo-Houses (1965–present)

Note. 1. ( ) shows the page numbers from McAlester and McAlester (1984)
2. This table also refers to other sources that include architecture.about.com, oldhouses.com, allbusiness.com,detroithomemag.com, antiquehome.org, ineedaninspector.com, and 45thparallelrealty.net.

Appendix C: Taxonomy of Architectural Styles of Michigan Houses

The major sources of the information were a book written by Virginia and Lee McAlester (1984) titled *A Field Guide to American Houses* and several architectural Internet sites such as architecture.about.com, oldhouses.com, allbusiness.com, detroithomemag.com, antiquehome.org, ineedaninspector.com, and 45thparallelrealty.net.

I. 1600-1820 Colonial Houses

Representative Styles in 1600–1820s	Included in Appendix
Postmedieval English	No
Dutch Colonial	Yes
French Colonial	Yes
Spanish Colonial	Yes
Georgian Colonial	Yes
Adam or Federal and	Yes
Adams	Yes
New England Colonial	Yes
German Colonial	No
Early Classical Revival	No

Dutch Colonial

It is an early-American-style, moderate-sized, 2- to 2½-story house with a gambrel roof and eaves that flare outward.

Features: Usually 1½ stories; rarely two stories; mainly located in New York State; stone or brick construction; Dutch doors; matching chimneys on each side; wide/slightly flared eaves or gambrel roof or gambrel roof with flared eaves. Figure 19-20 are modern variations of Dutch Colonial styles houses.

Figure 19. Dutch Colonial style house 1

Figure 20. Dutch Colonial style house 2

Photos by T. Mrozowski

French Colonial

During the early 1700s, French colonists settled in the Mississippi Valley, especially in Louisiana. An eclectic "Creole" architecture evolved, combining building traditions from France, the Caribbean, the West Indies, and other parts of the world. It was designed for hot and wet climates.

Features: Located in Louisiana and Mississippi; timber frame with brick or "bousillage"; thin wooden columns; wide porches called "galleries"; living quarters raised above ground level; wide hipped roof that extends over the porches; porches used as passageway between rooms; no interior hallways, and French doors.

Spanish Colonial

Settling in Florida, California, and the American Southwest, settlers from Spain and Mexico built these homes.

Features: Located in the American South/Southwest/California; one story; flat roof/roof with a low pitch; earth/thatch/clay tile roof covering; thick walls made with rocks/coquina/adobe brick coated with stucco; several exterior doors; this style house has small windows originally without glass; wooden or wrought iron bars across the windows; interior shutters; second story with recessed porches and balconies; interior courtyards; carved wooden brackets and balustrades; double hung windows.

Figure 21. A house reflecting main features of Spanish Colonial style

Photo by T. Mrozowski

Georgian Colonial

Georgian Colonial became the rage in New England and the Southern colonies during the 1700s. These homes imitated the larger, more elaborate Georgian homes which were being built in England. But the genesis of the style goes back much farther. During the reign of King George I in the early 1700s, and King George III later in the century, Britons drew inspiration from the Italian Renaissance and from ancient Greece and Rome.

Features: Square/symmetrical shape; paneled front door at center; decorative crown over front door; flattened columns on each side of door; five windows across front; paired chimneys; medium pitched roof; minimal roof overhang.

Figure 22. A house reflecting main features of Georgian style

Photo by S.-K. Kim and S. Space

German Colonial

German Colonial style houses were developed by immigrants from Germany and other European nations who settled along the Delaware River Valley area. Another name for this architecture is a bank house, which was popular for protecting the inhabitants from winter and summer climates.

Features: Most often found in New York/Pennsylvania/Ohio/Maryland; 2-foot thick walls made with sandstone; reinforced stone arches above the first floor windows and doors; hand-hewn beams pinned with wooden pegs; exposed half-timbering; flared eaves; massive wishbone-shaped chimney. Figure 23 show a modernized German Colonial style house.

Figure 23. German Colonial style house

Photos by T. Mrozowski

New England Colonial

In the late 1500s and early 1600s, when the first settlers came to North America, houses in England had steep roofs, massive chimneys, and details that had survived from medieval times.

Since these homes were constructed of wood, few original New England Colonials are still standing.

Features: Usually located in the northeastern United States; steep roof with side gables; lean-to addition with saltbox roof; narrow eaves; large chimney at the center; two stories, in some cases the second story slightly protrudes over the lower floor; wood framed with clapboard or shingles; small casement windows some with diamond-shaped panes; little exterior ornamentation.

Figure 24. A house reflecting New England Colonial style

Photo by T. Mrozowski

Federal and Adam House

Federal style buildings have curved lines and decorative flourishes. Federalist architecture was the favored style in the United States from about 1780 until the 1830s.

Features: Low-pitched roof or flat roof with a balustrade; windows arranged symmetrically around a center doorway; semicircular fanlight over the front door; narrow side windows flanking the front door; decorative crown or roof over front door; tooth-like dentil moldings in the cornice; Palladian window; circular or elliptical windows, shutters, decorative swags and garlands; oval rooms and arches.

Figure 25. Federal and Adam style house

Photos by T. Mrozowski

II. 1820–1880 Romantic Houses

Representative Styles in 1820–1880s	Included in Appendix
Greek Revival	Yes
Gothic Revival	Yes
Italianate	Yes
Exotic Revivals	No
Octagon	Yes

Greek Revival

Greek Revival architecture is known to begin with public buildings in Philadelphia. Greek Revival architecture sometimes called the National Style was widely popular at this time, and is present all over the United States. The fashionable Grecian style then spread by way of carpenters' guides and pattern books. Greek revival houses typically are symmetrical in shape and have a prominent use of columns on the façade or entry porch.

Features: Classical pediment over entry porch; symmetrical shape; heavy cornice; wide/plain frieze; bold/simple moldings; glazed door surround at main entrance; classical or square columns on front façade or at entry porch; decorative pilasters; three-part Palladian windows.

Figure 26. Greek Revival style house

Image adapted from McAlester and McAlester (1984, p. 178). Drawn by S.-K. Kim & S. Space

Gothic Revival

The earliest Gothic Revival homes were constructed of stone and brick. The Gothic Revival style imitated the great cathedrals and castles of Europe. However, few people could afford to build grand masonry homes in the Gothic Revival style. The availability of lumber and factory-made architectural trim in the United States resulted in a distinctly American version of Gothic Revival. Wood-framed Gothic Revival homes became America's dominant style in the mid-1800s.

Figure 27. Gothic Revival style house

Source: City of West Chicago; Architecture Department (2012).
www.westchicago.org/departments/gothicrevival.html

Features: Steeply pitched roof; steep cross gables; windows with pointed arches; vertical board and batten siding; one-story porch.

Italianate

Italianate style has several unique features. It has the decorative brackets evenly spaced and often paired, which are positioned underneath low-pitched roofs with wide overhanging eaves. The brackets are often placed in front of an embellished band trim, or a row of awning windows set between the eave brackets can be found.

Features: Sash windows with one or two panes; paired and triple windows or a bay window; one-story porches; square post supports with beveled corners and small porches; windows are usually tall and narrow; some arched or curved at the top having decorative crowns and hood moldings.

Figure 28. Italianate style house 1

Image adapted from McAlester and McAlester (1984, p. 210). Drawn by S.-K. Kim and S. Space

Figure 29. Italianate style house 2

Photo by S.-K. Kim

Octagon House

Historians often credit writer Orson S. Fowler for the Octagon style. Fowler believed that Octagon houses increased sunlight and ventilation and eliminated "dark and useless corners." After Fowler published his book *The Octagon House, A Home for All*, plans for Octagon style houses were widely circulated. However, Fowler did not actually invent the idea of octagonal design. Thomas Jefferson used the octagonal shape for his summer home, and many Adam and Federal homes included octagonal rooms. Only a few thousand Octagon houses were built, and few remain.

Features: Octagonal or rounded shape usually (but not always) with eight sides; cupola; porches that are usually one story.

III. 1860–1900 Victorian Houses

Representative Styles in 1860–1900s	Included in Appendix
Second Empire	Yes
Stick	Yes
Queen Anne	Yes
Shingle	Yes
Richardsonian-Romanesque	Yes
Folk Victorian	Yes
Eastlake House	Yes
Victorian Sticks	Yes

Second Empire or Mansard

This was a dominant style for American houses built between 1860 and 1880 (McAlester and McAlester 1984, p. 242).

Features: Mansard roof; dormer windows project like eyebrows from roof; rounded cornices at top and base of roof; brackets beneath the eaves; balconies and bay windows; cupola;

patterned slate on roof; wrought iron cresting above upper cornice; classical pediments; paired columns; tall windows on first story; small entry porch.

Figure 30. Second Empire style house
Photo by T. Mrozowski

Stick Style

The Stick style is characterized by the widespread use of decorative milled detailing and varying uses of wood wall surfaces. The most important features of Stick style houses are on the exterior wall surfaces. Instead of three-dimensional ornamentation, the emphasis is on patterns and lines. Because the decorative details are flat, they are often lost when homeowners remodel. These dwellings are similar in form to the Queen Anne style and generally have high pitched gable roofs and asymmetrical floor plans.

Features: Large porches with decorative railings; turned columns; applied vergeboards or spindles; second floor balconies and bay windows; windows and doors having decorative glass and surrounds; embellished eaves with milled woodwork such as brackets; sunburst designs; attached vergeboards.
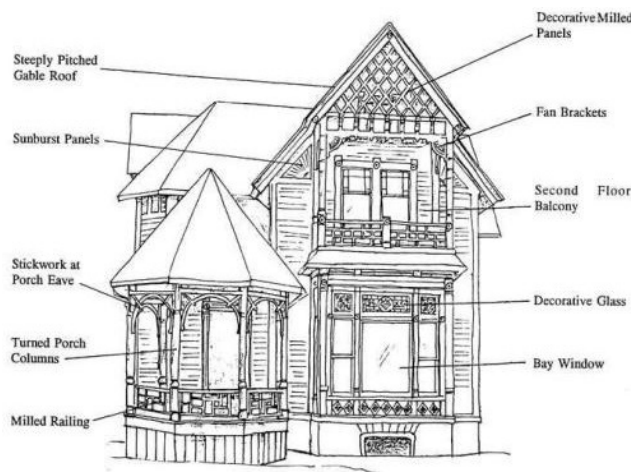
Figure 31. Stick style house

Source: City of Elgin; Community Development Department (2002).
www.westchicago.org/departments/Stick.html

Queen Anne

The Queen An ne is famous for the most elaborate and eccentric of all the Victorian house styles. Queen Anne is often called Romantic and feminine. Some are lavished with gingerbread while others are made of brick or stone. Many have turrets but they are not necessary to make a house a Queen Anne.

Features: Bay windows; balconies; stained glass; turrets; porches; brackets; an abundance of decorative details combined in unexpected ways.

Figure 32. Queen Anne Style house

Photo by S.-K. Kim

Eastlake House

Eastlake houses are actually Queen Anne houses. They are called Eastlake because of the lacy, ornamental details. The ornamental style is named after the famous English designer, Charles Eastlake, who was famous for making furniture decorated with fancy spindles. Eastlake details can be found on a variety of Victorian era houses.

Figure 33. Eastlake house

Photo by T. Mrozowski

Shingle House

Shingle Style houses can take on many forms. Some have tall turrets, suggestive of Queen Anne architecture. Some have gambrel roofs, Palladian windows, and other Colonial Revival details. Some Shingle houses have features borrowed from Tudor, Gothic and Stick styles. But, unlike those styles, Shingle architecture is relaxed and informal. Shingle houses do not have the lavish decorations that were popular during the Victorian era.

Features: Continuous wood shingles on siding and roof; irregular roof line; cross gables; eaves on several levels; porches; asymmetrical floor plan; wavy wall surface; pattern shingles; squat half-towers; Palladian windows; roughhewn stone on lower stories; stone arches over windows and porches.

Figure 34. Shingle style house 1

Image adapted from McAlester and McAlester (1984, p. 288). Drawn by S.-K. Kim and S. Space

Figure 35. Shingle style house 2

Photo by S.-K. Kim

Richardson-Romanesque

The heavy Romanesque style was especially suited for grand public buildings. However, Romanesque buildings, with massive stone walls, were expensive to construct. Only the wealthy adopted the Richardsonian-Romanesque style for private homes.

Features: Constructed of rough-faced square stones; round towers with cone-shaped roofs; columns and pilasters with spirals and leaf designs; low broad "roman" arches over arcades and doorways; patterned masonry arches over windows.

Figure 36. Richardsonian-Romanesque house

Photo by T. Mrozowski

Folk Victorian

Many Folk Victorian houses were adorned with flat, jigsaw cut trim in a variety of patterns. Others had spindles, gingerbread, and details borrowed from the Carpenter Gothic style. With their spindles and porches, some Folk Victorian homes may suggest Queen Anne architecture. But unlike Queen Anne style, Folk Victorian houses are orderly and symmetrical houses. They do not have towers, bay windows, or elaborate moldings.

Features: Square, symmetrical shape; brackets under the eaves; porches with spindle work or flat/jigsaw cut trim; carpenter gothic details; low-pitched/pyramid shaped roof; front gable and side wings.

Figure 37. Folk Victorian style house/ 0654

Photo by T. Mrozowski

IV. 1880–1940 Eclectic Houses

Representative Styles in 1880–1940s	Included in Appendix
Anglo-American, English, and French Period Houses	
Colonial Revival	Yes
Cape Code Colonial	Yes
Neoclassical	Yes
Tudor/Tudor Revival	Yes
Chateauesque	No
Beaux Arts	Yes
French Eclectic (French	Yes
Normandy/French Provincial)	Yes
Mediterranean Period Houses	
Italian Renaissance	No
Mission	No
Spanish Eclectic	No
Monterey	No
Pueblo Revival	No
Renaissance Revival	Yes
Modern Houses	Yes
Prairie	Yes
Craftsman	Yes
Bungalow	Yes
American Four Square	Yes
Art Moderne/Modernistic	Yes
International	Yes
Bauhaus	

Colonial Revival

The Colonial Revival style was one of the most popular architectural styles of the early 20th century. During the 1890s there was a renewed interest in the architectural forms of Colonial America.

Features: Built with symmetrical floor plans and classically detailed formal porches; and columns and pilasters in Doric, Ionic, Corinthian, and Tuscan orders; eave dentils; pedimented windows and doors; houses are constructed both of brick and frame and are generally two stories in height.

Figure 38. Colonial Revival style house

Source: City of Elgin; Community Development Department (2002).
www.westchicago.org/departments/HP_WCA.html

Cape Cod

Cape Cod is a type of Colonial Revival that was popular in the late 1800s and early 1900s. This style became especially popular during the 1930s. These small, economical houses were mass-produced in suburban developments across the United States. Twentieth century Cape Cod houses often have dormers. The chimney is usually placed at one end instead of at the center. The shutters on modern Cape Cod houses are strictly decorative; they can't be closed during a storm.

Features: Steep roof with side gables; small roof overhang; 1 or 1½ stories; made of wood and covered in wide clapboard or shingles; large central chimney linked to fireplace in each room; symmetrical appearance with door in center; dormers for space/light/ventilation; multipaned/double-hung windows; shutters; formal/center-hall floor plan; hardwood floors; little exterior ornamentation.

Figure 39. Cape Code style house

Photo by A. Harrell-Seyburn

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Neoclassical House

The word *Neoclassical* is often used to describe an architectural style, but Neoclassicism is not actually any one distinct style. Neoclassicism is a trend, or approach to design, that can describe several very different styles. A Neoclassical house may resemble any of these historic styles: Federal, Greek Revival, Georgian.

Figure 40. Neoclassical style house

Source: City of Elgin; Community Development Department (2002).
www.westchicago.org/Departments/images/NeoClassical.jpg

Tudor Revival House

Tudor style houses often feature striking decorative timbers. These timbers hint at—but do not reproduce—medieval construction techniques. In medieval houses, the timber framing was integral with the structure. Tudor Revival houses, however, merely suggest the structural framework with *false* half-timbering. This decorative woodwork comes in many different designs, with stucco or patterned brick between the timbers.

Features: Decorative half-timbering; steeply pitched roof; prominent cross gables; tall/narrow windows; small window panes; massive chimneys often topped with decorative chimney pots.

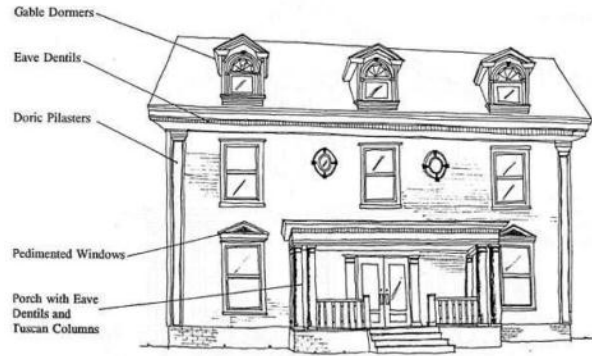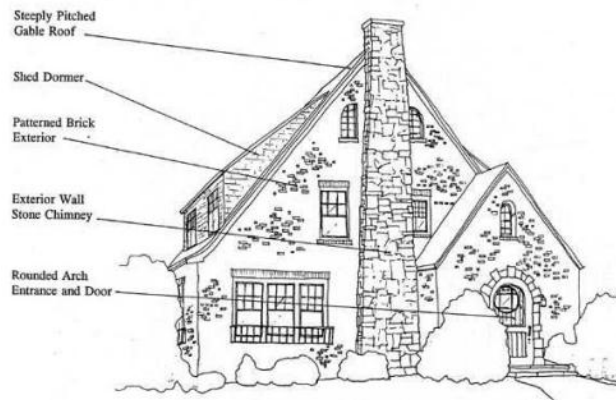**Figure 41. Tudor Revival style house 1**

Source: City of Elgin; Community Development Department (2002).
www.westchicago.org/Departments/images/Tudor.jpg

Figure 42. Tudor Revival style house 2

Photo by S.-K. Kim and S. Space

Beaux Arts

This style is also known as Beaux Arts Classicism, Academic Classicism, or Classical Revival. It is a late and eclectic form of Neoclassicism. It combines classical architecture from ancient Greece and Rome with Renaissance ideas. Beaux Arts is characterized by order, symmetry, formal design, grandiosity, and elaborate ornamentation. In the United States, the Beaux Arts style led to planned neighborhoods with large, showy houses, wide boulevards, and vast parks. Due to the size and grandiosity of the buildings, the Beaux Arts style is known to be most commonly used for public buildings like museums, railway stations, libraries, banks, courthouses, and government buildings.

Features: Massive and grandiose; constructed with stone; balustrades; balconies; columns; cornices; pilasters; triangular pediments; lavish decorations including swags/medallions/ flowers/shields; grand stairway; large arches; symmetrical façade.

Figure 43. Beaux Arts style house

Image adapted from McAlester and McAlester (1984, p. 385)

French Normandy

Some French style homes borrow ideas from Normandy, where barns were attached to the living quarters. Grain or ensilage was stored in a central turret.

Features: A cozy and romantic style that features a small round tower topped by a cone-shaped roof; other Normandy homes resemble miniature castles with arched doorways set in imposing towers; some 20th-century French Normandy homes have decorative half-timbering like Tudor style houses; many houses influenced by French styles do not have a dominant front gable.

Figure 44. A house reflecting main features of French Normandy style

Photo by S.-K. Kim and S. Space

French Provincial

French Provincial houses tend to be square and symmetrical. They resemble small manor homes with massive hipped roofs and window shutters. Frequently, tall second-floor windows break through the cornice. French Provincial homes do not have towers.

Figure 45. French Provincial style house (Modern Interpretation)

Photo by T. Mrozowski

French Eclectic

French Eclectic homes combine a variety of influences from the architecture of France. The most telling feature of French Eclectic is its roof. It is steeply pitched, hipped, and the eaves are often flared. This style may be both symmetrical and quite formal, or asymmetrical and somewhat rambling as are many French farmhouses. There are many similarities to the Tudor style that

occurred at the same time, such as half-timbering and materials used. This style is most easily distinguished from the Tudor by the absence of a front-facing cross gable.

Features: Tall, steeply pitched, hipped roof; eaves commonly flared upward; masonry wall cladding of stone or brick; often stuccoed; rounded Norman towers are common.

 Massive chimneys; range of architectural detail including quoins, pediments, and pilasters; windows may be casement or double hung and French doors are used.

Figure 46. French Eclectic style house

Photo by T. Mrozowski

Renaissance Revival House

The Renaissance Revival style was popular during two separate phases. The first phase, or the First Renaissance Revival, was from about 1840 to 1885, and the Second Renaissance Revival, which was characterized by larger and more elaborately decorated buildings, was from 1890 to 1915. Due to the expensive materials required and the elaborate style, Renaissance Revival was best suited for public and commercial buildings, and very grand homes for the wealthy.

Features: Cube-shaped; balanced and symmetrical façade; smooth stone walls made from finely cut ashlar or smooth stucco finish; low-pitched hip or mansard roof; roof topped with balustrade.
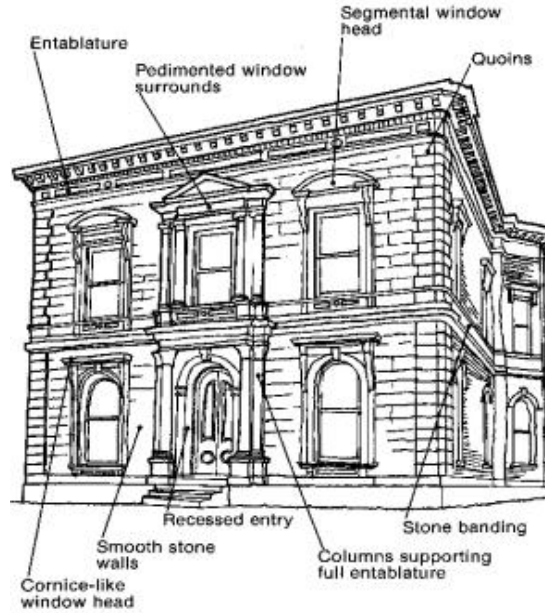
Figure 47. Renaissance Revival house

Source: City Planning and Buildings, City of Cincinnati,
www.cincinnati-oh.gov/planning/historic-conservation/major-architectural-styles/renaissance-revival-1845-to-1885-1890-to-1915/

Prairie Style

The Prairie style originated in Chicago and is concentrated in the early 20th-century suburbs.

Features: Low-pitched roof; usually hipped; with widely overhanging eaves; typically two stories, with one-story wings or porches; eaves, cornice, and façade detailing emphasizes horizontal lines; houses in this study often include massive square porch supports.

Figure 48. Prairie style house

Photo by S.-K. Kim

Craftsman (Arts and Crafts)

The Craftsman style was the dominant style of small house built throughout the country in the first quarter of the 20th century. The style originated and is concentrated in southern California.

Spread throughout the country by pattern books and magazines. Faded from favor after the mid-1920s with few built after 1930.

Features: Low-pitched gable roof (occasionally hipped) with wide, unenclosed overhanging eaves and roof rafters exposed; decorative (false) beams or braces are commonly located under gables; porches, either full-or partial-width, included a roof supported by tapered square columns or pedestals that extend to ground level (without a break at the level of the porch.)

Figure 49. Craftsman style house 1

Image adapted from McAlester and McAlester (1984, p. 452). Drawn by S.-K. Kim and S. Space

Figure 50. Craftsman style house 2

Photo by S.-K. Kim

Bungalow

The Bungalow refers to any small 20th-century home that uses space efficiently. It takes on a variety of shapes and styles. This is a subtype of the Craftsman style.

Features: Detached usually low rise, 1–1½ stories with porch; a low-pitched roof and horizontal shape; most of the living spaces are on the ground floor with living room at the center; rooms connect without hallways and have built-in cabinets, shelves, and seats.

Figure 51. Bungalow style house

Photo by S.-K. Kim

American Four Square

The American Four Square style borrows design elements from the Prairie and Arts and Crafts styles. It is also known as the "Prairie Box" or Transitional Pyramid." It was a popular mail-order house from Aladdin or Sears.

Features: Characteristically plain with a square or boxy design and 2½ stories with four large rooms per floor; a central dormer and porch; low-hipped roof with deep overhang; full-width porch with wide stairs; referred to as the "Prairie Box" or "Transitional Pyramid."

Figure 52. American Four Square style house 1

Photo by S.-K. Kim

Figure 53. American Four Square style house 2

Photo by S.-K. Kim

Art Moderne

Modernistic styles were built from 1920–1940. After 1930, Art Moderne became the prevalent Modernistic form. Many houses were built in the style although it was never common. Scattered examples can be found throughout the country.

Features: Smooth wall surface, usually of stucco; a flat roof, typically with a small ledge (coping) at the roof line; asymmetrical façade; horizontal grooves or lines in wall and horizontal balustrade elements giving horizontal emphasis to the structure.

Figure 54. Art Moderne style house

Photo by S.-K. Kim and S. Space

International

International Style was avant-garde and primarily architect-designed style that is relatively rare.

Features: Typically walls are not used for structural support; exterior walls are curtains hung over a structural steel skeleton; façade is asymmetrical; a flat roof, usually without ledge (coping) at roof; windows (usually metal casements) set flush with the outer wall; walls are characteristically smooth and unornamented with no decorative detailing at doors or windows.

Figure 55. Modern interpretation of the International Style house

Photo by T. Mrozowski

Bauhaus

Bauhaus architects rejected "bourgeois" details such as cornices, eaves, and decorative details. Classical architecture in its most pure form: without ornamentation of any kind.

Features: Flat roofs; smooth façades; cubic shapes; white, gray, beige, or black colors; open floor plans; furniture is functional.

Figure 56. Bauhaus style house

Photo by T. Mrozowski

V. Since 1940s

Representative Styles Since 1940s	Included in Appendix
Modern	Yes
Neoeclectic	Yes
Contemporary	Yes
Folk/Contemporary	Yes
A-Frame	Yes
Neo-Colonial	Yes
Neo-Mediterranean	No

Modern includes Minimal Traditional, Ranch, Split-Level Ranch, Contemporary, and Shed, Found throughout the country. Neoeclectic includes Mansard, Neocolonial, Neo-French, Neo-Tudor, Neo-Mediterranean, Neoclassical Revival, and Neo-Victorian, Spread in the country.

Contemporary folk includes: Mobile Homes, Quonset Huts, A-Frames, and Geodesic Domes (McAlester and McAlester 1984, pp. 477–497).

Ranch

The Ranch style was the dominant style throughout the country during the 1950s and 1960s. Style is loosely based on the Spanish Colonial styles of the southwest with modifications influenced by the Craftsman and Prairie styles of the early 20th century.

Features: Asymmetrical one-story shapes with low-pitched roof that is either, hipped, cross-gabled, or side-gabled; moderate or wide eave overhanging, either boxed or open, with exposed rafters; wood and brick cladding; porches have decorative iron or wooden supports; ribbon windows and a large picture window in the living room are typical; partially enclosed courtyards or patios.

Figure 57. Ranch style house 1

Image adapted from McAlester and McAlester (1984, p. 476). Drawn by S.-K. Kim and S. Space

Figure 58. Ranch style house 2

Photo by S.-K. Kim

Raised Ranch

The Raised Ranch is a variation of the Ranch Style. The Raised Ranch is a practical and flexible style that fulfills a need for space and organization.

Features: Two stories with partially submerged basement including finished rooms and windows; characteristically asymmetrical; an attached garage; low-pitched gable roof; little decorative detailing; large windows including double-hung, sliding, and picture.

Figure 59. Raised Ranch style house

Photo by S.-K. Kim

Split-Level Ranch

The Split-Level Ranch is a multistory variation of the Ranch style. Found throughout the country although less common in the southern and western states.

Features: A two-story unit intercepted at mid-height by a one-story wing to make three floor levels of interior space; decorative detailing of vaguely colonial inspiration with horizontal lines; low-pitched roof; overhanging eaves; a wide variety of wall-cladding often mixed in a single house.
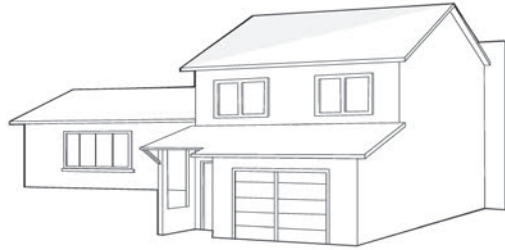
Figure 60. Split-level ranch style house 1

Image adapted from McAlester and McAlester (1984, p. 476). Drawn by S.-K. Kim and S. Space

Figure 61. Split-level ranch style house 2

Photo by S.-K. Kim

Contemporary

Contemporary homes are designed for today's lifestyles with huge windows and large, open spaces.

Features: Odd irregular shape that lacks ornamentation; tall, oversized windows; some with trapezoid shapes; an open floor plan; natural materials including cedar or stone are common.

Figure 62. Contemporary style house 1

Photo by T. Mrozowski

Figure 63. Contemporary style house 2

Photo by T. Mrozowski

A-Frame

A-Frame style is a type of modern folk house used more for vacation and second homes than for permanent dwellings.

Features: Simple to construct and adapted to a variety of materials; typically sidewall and roof-wall junctions are omitted; the gabled roof continues to ground level on two sides.

Neo-Colonial

Neo-Colonial is a Neoeclectic house style that is a loose interpretation of the traditional Colonial style. The style has been continuously popular but never dominant. It is overshadowed by the Ranch and other modern styles.

Features: Roof pitches that are either lower or steeper than traditional colonial; symmetrical façade lacks the regularly spaced patterns of window placement in Georgian and Adam houses; widely overhanging eaves; metal windows; free interpretation of colonial style details including door surrounds, colonnaded entry porches, and dentiled cornices.

Figure 64. Neo-Colonial style house

Image adapted from McAlester and McAlester (1984, p. 486). Drawn by S.-K. Kim and S. Space

Appendix D: Analysis of the Intensive Housing Survey Report

Introduction

"The Ann Arbor Intensive Survey" (Ferraro, 1996) is a comprehensive report of historic structures in the following project area of 85 acres. as described by the report in two parts: "the first part being to the west and the second part being to the east of Plymouth Road, both north of the Huron River in Ann Arbor. On the west side of Plymouth Road, the Surveyed area is bounded on the west by Wright and Pontiac Streets, on the north by Taylor and John A. Wood, on the east by Traver and on the south by Moore and Swift. On the east side of Plymouth Road, the survey area begins at the base of Broadway Hill excluding the shopping center on the east side, includes all of Broadway to the top of the hill approximately one block past Cedar Bend, as well as Jones Street south of Arbor Springs Water Company."

The purpose of the survey was to methodically assemble, in a single resource, material including both the necessary historical data and contexts for a committee to consider the possible establishment of a new local historic district in Ann Arbor. In addition, the data were compiled for the purpose of providing the necessary information required for Michigan Historic Center Inventory Cards.

The survey began with a preliminary context report on October 31, 1995 followed by four drafts first submitted on February 29, 1996, a second on March 19, 1996, and a third on April 4, 1996. The final draft of the survey was submitted on June 15, 1996.

The survey research was conducted in three parts. The first included preliminary research followed by pre-field study that consisted of general readings on Ann Arbor's history combined with archival research. Field work followed with site visits and onsite documentation of each site in the form of a descriptive questionnaire that recorded significant features of each structure including the following criteria, style, materials, foundation, outbuildings and other noteworthy features. This was followed by post-field research focused on resolving questions that arose during the preliminary research and field work phases in particular date of construction and name of first owner.

The boundary for the project area was determined by the Ann Arbor Historic Preservation Coordinator and the State of Michigan Historical Center. Tax assessors' records, deed records, and plat maps were utilized to determine addresses and first owners, especially of the oldest residences.

It was critical that the survey differentiate between contributing, structure within a historic district that contributes to the historic character of the district, and non-contributing. For the purposes of this survey criteria for contributing buildings were twofold. First structures within the project area were required to be at least 50 years old at the time of the survey and second had retained their historic integrity in accordance with the National Register eligibility requirements.

The report was conducted by Historic Consultant, Sharon Ferraro, who meets the requirements of 36 CFR 61 as an Architectural Historian. Ferraro is responsible for all pre-field archival research, onsite field documentation, and post-field archival research.

Dominant Housing Styles From the Survey

Preliminary research led to the identification of five historical contexts, including architecture, agriculture, commerce, industry, and exploration/settlement. These contexts were detailed in the Preliminary Context Report of October 31, 1995. The list of contexts was expanded following pre-field work research to also include education and two ethnic contexts: African American and German American. The commerce context was eliminated.

The survey findings indicate that there are enough contributing buildings to establish a historic district both cohesively and thematically, in accordance with the standards for historic district eligibility. The survey recommends a National Register district nomination for the collection of homes located at the southern portions of Pontiac, Traver, Jones, and Broadway Streets that date to the earliest period of the subject area. Pre-field research established that the mix of building types anticipated included a few non-contributing commercial buildings, a couple industrial, with the greatest majority being residential in the project area.

Analysis of the final report indicates that there are 10 distinct architectural styles among the residential buildings documented in the survey: Greek Revival, Vernacular, Ranch, Cape Cod, Cottage, Bungalow, Colonial Revival, Queen Anne, Italianate, and Craftsman. Of these 10 architectural styles, three—Greek Revival, Vernacular, and Ranch—are the most dominant. With a total of 45 houses, the Greek Revival style is the most dominant of the three styles occurring at the highest rate of 19.6%. Vernacular is the second with 33 houses identified at an occurrence of 14.3%, and the third most dominant style is Ranch at 27 houses with a rate of 11.7%. Table 19 presents dominant housing styles based on the Intensive Housing Survey.

Table 19. Frequency of Housing Styles From the Intensive Housing Survey Report

Style	Frequency	%
Greek Revival	45	19.6
Vernacular	33	14.3
Ranch	27	11.7
Cape Cod	18	7.8
Cottage	15	6.5
Bungalow	12	5.2
Colonial Revival	10	4.3
Queen Anne	8	3.5
Italianate	6	2.6
Craftsman	6	2.6
Subtotal	180	78.3
Others	50	21.7
Total	230	100

Examples Housing Styles From the Survey Report

The houses featured in Table 20 are representative of the dominant styles found in Ann Arbor, including Greek Revival, Vernacular, Ranch, and Cape Cod. Houses are included in the Ann Arbor Northside Intensive Level Survey by Sharon Ferraro (1996). The document is an inventory of all structures in the historic Northside Neighborhood of Ann Arbor written for the purpose of

establishing a local historic district in accordance with National Register requirements. The Michigan State Historic Preservation Office furnished the research team with this survey as a resource to determine dominant styles in Ann Arbor.

**Table 20. Ann Arbor Featured Homes and General Characteristics
From the Intensive Housing Survey**

Significant Date(s)	Address	Image	Style Name and Features
1830–1860	Pontiac Dr., Ann Arbor	*Description*: Rectangular, two-story, gable front, wood frame house resting on a stone foundation. The front façade has a left side entrance door flanked by sidelights and topped by a transom. The windows are 2/2 and double hung. There is a small shed roof addition at the rear.	Style: Greek Revival General Features: Pedimented gable, symmetrical shape, heavy cornice, wide/plain frieze, bold/simple moldings Source: McAlester and McAlester (1984, p. 178). Foundation: Stone Exterior Walls: wood clapboard Roof: Asphalt Shingle Source: Ferraro (1996).
1838	Pontiac Dr., Ann Arbor	*Description*: Rectangular, front gable, one and a half story, wood frame house on a stone foundation with 1/1 double hung windows. An addition on the left (south) side includes sun porch and a solar collector. Trims on the house include a wide frieze board and return cornices front and rear. An early gable roof addition at the rear has no frieze board. A small front entry porch is on the left side, with a gabled roof supported on square columns and with a square spindled rail.	Style: Greek Revival Foundation: Stone Exterior Wall: Shingle Roof: Asphalt Shingle Source: Ferraro (1996).

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Significant Date(s)	Address	Image	Style Name and Features
1838	Pontiac Dr., Ann Arbor	*Description*: T-gable, two-story, wood frame house with a large gables wing whose front peak shows over the ridgeline of the front portion. The windows are all new 1/1 and double hung except for the sliding frieze windows. The large, centered entry porch has a hipped roof supported on square posts resting on a stone balustrade with a concrete cap. On the left rear wall was probably originally a small entry porch has been enclosed for living space.	Style: Greek Revival Foundation: Stone Exterior Wall: Vinyl Siding Roof: Asphalt Shingle Source: Ferraro (1996)
1855–1898	Pontiac Dr., Ann Arbor	*Description*: Rectangular, end gable, 1 and 1½-story, wood frame house on a stone foundation recently lengthened and roof raised to a 45-degree pitch. House is covered with new cedar clapboards overall. Windows are new 1/1 double hung with two frieze windows over the porch. An ell shaped porch wraps from the left (south) end around the front with a hipped roof supported by turned columns and Gothic scrollwork brackets resting directly on the porch floor. There are no balustrades as the porch sits less than a foot off the ground. A shed roof addition at the rear gives the house almost a saltbox shape, and the new clapboards disguise the joint.	Style: Greek Revival Foundation: Stone Exterior Wall: Wood clapboard Roof: Asphalt Source: Ferraro (1996)

Significant Date(s)	Address	Image	Style Name and Features
1850–1896	Pontiac Dr., Ann Arbor	 *Description*: Rectangular, 1½-story, end gable wood frame house with single story gable roofed addition forming a T at the rear. House retains its original return cornices and 1/1 double-hung windows, but vinyl siding has (probably) covered the original frieze board and frieze windows. A small gable roofed vestibule addition is centered on the front of the house.	Style: Greek Revival Foundation: Stone Exterior Walls: Vinyl Siding Roof: Asphalt Shingle Source: Ferraro (1996)
1838	Pontiac Dr., Ann Arbor	 *Description*: Rectangular, end gable, 1 and 1½-story, wood frame house with a stucco exterior and a rear shed addition. The house retains it return cornices but the frieze boards and possibly frieze windows are gone. Facing Pontiac is a full width shed dormer with small double hung windows and asbestos shingles. The full width front porch has a hipped roof supported on Tuscan columns resting on the porch floor. Front facing picture windows on the first floor replace the original smaller windows.	Style: Greek Revival Foundation: Unexposed Exterior Walls: Stucco Roof: Asphalt Shingle Source: Ferraro(1996)
1850, 1905	Pontiac Dr., Ann Arbor		Style: Vernacular Gable-Front Foundation: Stucco Exterior Walls: Asbestos Siding Roof: Asphalt Shingle Source: Ferraro (1996)

Significant Date(s)	Address	Image	Style Name and Features
		Description: Rectangular, gable front, two-story, wood frame house on a stucco foundation with a full width, hipped roof porch. First floor windows are 2/2 and double hung, second floor are 1/1 and double hung.	
1917	Pontiac Dr., Ann Arbor	*Description*: Rectangular, gable front, 1½-story, wood frame house on a stucco foundation covered with painted asbestos shingle siding. One the right (north) wall, a gabled wall dormer breaks the eave line. Windows are all double hung and 1/1. A low pitched hipped roof spans the house.	Style: Vernacular Gable-Front General Features: Narrow, two story with relatively steep roof pitch and gable parallel to street Source: McAlester and McAlester (1984. p. 178) Foundation: Stucco Exterior Walls: Asbestos Shingle Roof: Asphalt Shingle Source: Ferraro (1996)
1850	Pontiac Dr., Ann Arbor	*Description*: Rectangular, 1 and 1½-story, end gable, wood frame house on a stone foundation covered with vinyl siding with a single story gabled addition at the rear extended with a shed roof. A full width hipped roof porch is supported by square columns resting on a concrete block balustrade finished with screen/storms to the eave line. The original return cornices remain and the second story windows are 6/6 double hung and probably original.	Style: Greek Revival Foundation: Stone Exterior Walls: Vinyl Siding Roof: Asbestos Shingle Source: Ferraro (1996)

Significant Date(s)	Address	Image	Style Name and Features
No date	Pear Dr., Ann Arbor,	 *Description*: Single-story, rectangular, flat roofed ranch. *General Features:* Asymmetrical one-story shapes with low pitched roof that is either hipped, cross-gabled or side gabled. Has moderate or wide eave overhanging, either boxed or open, with exposed rafters, Typically includes wood and brick cladding. Porches have decorative iron or wooden supports. Ribbon windows and large picture window in living area are typical as well as partially enclosed courtyards or patios.	Style: Ranch Foundation: Unexposed Exterior Walls: Concrete Block Roof: None indicated Source: Ferraro (1996) Source: McAlester and McAlester (1984, p. 479)
No Date	Pear Dr., Ann Arbor	 *Description*: Rectangular, 1½-story, side gable, wood frame house with gabled hood over front door. *General Features:* Steep roof with side gables, lean-to addition with saltbox roof, narrow eaves, large chimney, two stories, in some cases the second story slightly protrudes over the lower floor, wood framed with clapboard or shingles, small casement windows some with diamond shaped panes, little exterior ornamentation.	Style: Cape Cod Foundation: Unexposed Exterior Walls: Wooden Clapboard Roof: Asphalt Shingle Source: Ferraro (1996) Source: McAlester and McAlester (1984, p. 78)

Significant Date(s)	Address	Image	Style Name and Features
No Date	Pear Dr., Ann Arbor	*Description*: Rectangular, 1-2 story, side gable wood frame house.	Style: Split-level Ranch Foundation: Unexposed Exterior Walls: None indicated Roof: None indicated Source: Ferraro (1996)
No Date	Pear Dr., Ann Arbor	*Description*: Rectangular, side gable, one story, wood frame house.	Style: Ranch Foundation: Unexposed Exterior Walls: Vinyl Siding Roof: Asphalt Shingle Source: Ferraro (1996)

The research team reviewed the data systematically organized by building in the survey. The team consolidated the data into a spreadsheet by address, year, architectural style, foundation material, exterior wall material, and roof materials for each of the 240 structures included in the survey. This data sheet is presented in Table 21.

Style designations for these houses was determined by author of the Ann Arbor Northside Intensive Level Survey, Historic Consultant Sharon Ferraro, who assigned houses with the defined residential style that they most closely resemble in accordance with their dominant characteristics. These characteristics included similar materials, architectural detailing, massing, and/or other features associated with a specific defined residential style. Many of these houses have been altered from their original design overtime so that they, in some cases, subtly resemble the defined residential style they have been designated in the Ann Arbor Northside Intensive Survey. Thus these houses, because of their unique history and modifications that transformed them to what they are today, are variations on defined residential styles.

The team visited Ann Arbor and the houses included in the survey. Houses that photographed well and were good representations of the dominant styles, including Greek Revival, Vernacular, Ranch, and Cape Cod, were included in Table 20.

Table 21. Housing Intensive Survey Data

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
1	Ranch	Brick	Asphalt	Unexposed	
2	Cottage- Gable Front	Aluminum siding	Asphalt	Stucco	Altered with siding and picture window
3	Dutch Colonial Revival- Albany	Clapboard (1st floor) shingle (2nd floor)	Asphalt, diamond lock	Stucco	
4	Modern Rustic	Wood, vertical siding	Asphalt	Concrete block	
5	Greek Revival	Asbestos siding	Asphalt shingle	Stone/Stucco	Built before 1860, typical small Greek Revival House
6	Vernacular – Tri-gable Ell	Asbestos siding	Asphalt shingle	Stone	Built 1894
7	Ranch	Brick	Asphalt	Concrete block	
8	Colonial Revival- Federal	Brick veneer	Asphalt	Stucco	
9	Dutch Colonial Revival	Brick (1st floor), Asbestos tile (2nd floor)	Asphalt	Stucco	Represents the Dutch colonial style in the neighborhood
10	Greek Revival	Aluminum siding	Asphalt	Brick	Excellent example of side gable Greek Revival
11	Craftsman- Greek Revival	Asbestos shingle	Asphalt	Stucco	Good example of a house transformed by owners in different eras, from Greek Revival to a Craftsman
12	Greek Revival	Asbestos siding	Asphalt tile	Stucco	Originally a barn built in the same style as the family house nearer Broadway, a frequent occurrence at the time it was built
13	Greek Revival	Asbestos shingle (1st floor) wide wooden clapboard (2nd floor)	Asphalt shingle	Stone	Originally fine example of a small Greek Revival house with Queen Anne modifications. Much of the character of the house was lost with recent alterations
14	Greek Revival	Asbestos siding	Interlock asphalt	Brick	Simple Greek Revival , despite siding, continues to represent its era in the neighborhood
15	Vernacular- Gable Front	Clapboard (1st floor), shingles (2nd floor)	Asphalt	Stucco	A fine example, with few modifications, of a simple early twentieth century house
16	Vernacular- Gable Front	Asphalt brick	Asphalt	Stone block	Simple workers house
17	Greek Revival	Asbestos shingle	Asphalt shingle	Unexposed	Simple, nearly intact Greek Revival represents the earliest wave of post pioneer homebuilding,
18	Greek Revival	Clapboard	Asphalt	Stucco	Excellent intact example of Greek Revival house
19	Modern-	Vinyl siding	Asphalt shingle	Concrete	

[2] The number was assigned corresponding to the house order in the original report.

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
	Double Gable Cottage			block	
20		N/A	N/A	N/A	
21	Greek Revival	Aluminum siding	Asphalt shingle	Stone	Simple Greek Revival farmhouse but significantly altered
22	Greek Revival	Wood frame	Asphalt	Unexposed	Poor physical condition but retains many important Greek Revival features
23	Dutch Colonial Revival	Vinyl siding	Asphalt shingle	Stucco	A fine example of an extremely simple Dutch Colonial Revival house
24	Queen Anne-Cottage	Asbestos siding	Asphalt shingle	Stone block	Queen Anne cottage, stripped of its trim, but still representative of a simple type of workers home
25	Greek Revival	Stucco	Asphalt	Stucco	Except for the replacement foundation for the front porch and rails, this house still exhibits the characteristics of a transitional Queen Anne with colonial Revival trims
26	Greek Revival	Wooden clapboards	Asphalt	Stucco	A classic Greek Revival cottage exceptionally well preserved representative of the simple style and shape of homes in Lower Town in the mid-nineteenth century
27	Albany Dutch Colonial	Wide wood clapboards	Asphalt	Stucco	Nice, nearly intact example of a simple house of the twenties
28	Queen Anne	Wooden clapboards	T-lock asphalt	Stone	Except for the replacement foundation for the front porch and rails, this house still exhibits the characteristics of a transitional Queen Anne with Colonial Revival trims
29	Vernacular-Gable Front	Clapboard/asbestos	Asphalt	Unexposed	Remarkably intact simple Queen Anne contributes to the neighborhood, marking the beginning on the north
30	Queen Anne	Wooden clapboard	Interlock asphalt	Stone blocks	Remarkably intact simple Queen Anne contributes to the neighborhood, marking the beginning of the second wave of home building on the north side
31	Contemporary rustic	Vertical wood siding	Asphalt roll	Concrete block	
32	Colonial Revival	Wooden clapboards	Asphalt shingle	Stone blocks	
33	Queen Anne	Wooden clapboards	Asphalt	Stone	Fine example of Queen Anne with an intact full width porch
34	Greek Revival	Clapboard asbestos	Asphalt	Stucco	
35	Greek Revival	Wooden clapboards	Asphalt shingle	Unexposed	
36	Vernacular – L-Gable	Vinyl siding	Asphalt	Stone block	Originally a nice Queen Anne, stripped of detail and sided. Significant as one of a set of three nearly identical houses with varying

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
					degrees of integrity
37	Greek Revival	Vinyl siding	Asphalt	Brick	A blend of at least three different house style, could represent the 19th century architecture of the north side all by itself
38	Italianate	Brick	Asphalt	Stone	Built 1862- the house itself represents the Italianate style admirably
39	Greek Revival	Vinyl siding	Asphalt	Stucco	
40	Greek Revival	Clapboard	Asphalt	Stucco	Built ca. 1855, A simple relatively unaltered Greek Revival, illustrates again the architecture and housing or the earliest part of Ann Arbor history
41	International	Concrete block	Flat asphalt	Unexposed	House represents a specific type of architecture with only one other like it in the neighborhood- the Jean Paul Slusser House on Pontiac
42	Craftsman	Stucco	Asphalt	Stucco	Built 1917, Spectacular, intact example of a Craftsman house
43	Cape Cod	Aluminum siding	Asphalt	Stucco	
44	Dutch Colonial Revival	Stucco (1st floor), shingle (2nd floor)	Asphalt	Stucco	Built 1919, House represents an unaltered gambrel roof Dutch Colonial Revival
45	Queen Anne	Aluminum siding	Asphalt	Stone	Simple Queen Anne, though altered, matches the unaltered 1427 Broadway and the modified 1509 Broadway
46	Bungalow	Clapboard (1st floor), shingle (2nd floor)	Asphalt	Stucco	
47	Georgian Colonial	Brick	Asphalt shingle	Stucco	Built 1936
48	Tudor Revival	Brick	Asphalt		Built 1932, Fine example of a simple, medium sized Tudor Revival house
49	Cape Cod	Stone veneer (1st floor), wooden clapboard (2nd floor)	Clapboards	Stone veneer	Built 1940, One of the earliest examples of this style of simple house built on the north side - many more after WWII
50	Cape Cod	Asbestos shingle	Asphalt shingle	Unexposed	
51	Cape Cod	Asbestos shingle	Asbestos shingle	Unexposed	
52	Colonial Revival - Modern	Asbestos shingle	Asphalt shingle	Stucco	Built 1940, A late version of the enduring Colonial Revival style
53	Ranch - International	Concrete block	Asphalt shingle	Unexposed	
54	Georgian Colonial	Wooden clapboards	Asphalt shingle	Brick	Built 1940, Late version of the enduring Colonial Revival style
55	American Four Square	Asbestos shingle	Asphalt shingle	Stone	Built 1913, One of the few houses built on Broadway between 1910

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
					and 1920
56	Neo-Federal	Vinyl siding	Asphalt shingle	Concrete block	Built 1939, Simple Cape Cod
57	Cape Cod	Asbestos shingle	Asphalt shingle	Concrete block	Built 1939, Simple Cape Cod
58	Greek Revival	Wooden clapboard	Asphalt shingle	Stone	Built in 1845, Simple little farmers house
59	Greek Revival	Wooden clapboard	Asphalt shingle	Stone	Built 1845
60	Colonial Revival	Aluminum siding	Asphalt shingle	Stucco	Built 1927
61	Bungalow	Brick	Asphalt shingle	Concrete block	Built 1927, A very fine and intact example of a brick Craftsman Bungalow
62	Cape Cod-Ranch	Brick (1st floor), Aluminum siding (2nd floor)	Asphalt shingle	Concrete block	
63	Ranch	Brick	Asphalt	Concrete block	Built 1940, This style of Ranch house marks the beginning of another age of residential architecture
64	Cape Cod - split	Vinyl siding (1st floor), Asbestos shingle (2nd floor)	Asphalt shingle	Concrete block	
65	Tudor Revival	Brick	Asphalt	Concrete block	Built 1930, An earlier example of the residential Tudor Revival style
66	Bungalow	Vinyl siding over clapboards	Asphalt shingle	Concrete block (quarry faced)	Built 1923, Simple large bungalow
67	Cottage	Asbestos shingle	Asphalt shingle	Concrete block	
68	Duplex Ranch	Brick	Asphalt	Unexposed	
69	Duplex Ranch	Brick	Asphalt	Unexposed	
70	Vernacular	Asbestos/clapboard	Asphalt shingle	Concrete block	
71	Cape Cod	Wood shingle	Asphalt shingle	Stucco	
72	Cottage	Vinyl siding	Asphalt shingle	Stucco	Built 1930
73	Ranch			Unexposed	
74	Vernacular-Gable Front	Aluminum siding	Asphalt shingle	Stucco	Built 1870. Simple little early house on the 1870 plat map
75	Cape Cod	Aluminum siding	Asphalt shingle	Stucco	
76	Ranch	N/A	N/A	Unexposed	
77	Cottage	Asbestos shingle	Asphalt shingle	Stucco	Built 1926. Simple cottage for workmen and their families, relatively unchanged except for the siding
78	Cottage	Vinyl siding	Asphalt shingle	Concrete block	Built 1925 and except for modifications enclosing the porch, this house is an almost perfect match to its neighbors at 903 and 717 John A. Woods
79	Vernacular	Wooden clapboard	Asphalt shingle	Stone	Built 1898, Simple vernacular house, typical of many in the

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
					neighborhood
80	Rustic Contemporary	Vertical wood siding	Asphalt shingle	Concrete block	
81	Rustic Contemporary	Vertical wood siding	Asphalt shingle	Concrete block	
82	Rustic Contemporary	Vertical wood siding	Asphalt shingle	Concrete block	
83	Rustic Contemporary	Vertical wood siding	Asphalt shingle	Concrete block	
84	Cottage	N/A	N/A	N/A	
85	Greek Revival	Asbestos siding	Asphalt shingle	Unexposed	Built 1855, integrity of the house has been compromised by the replacement windows and asbestos siding
86	Greek Revival	Wooden clapboard	Asphalt shingle	Unexposed	Built 1830s, An intact example of what was probably a very common house type in the early part of the last century - represents the earliest part of Ann Arbor's history
87	Italianate	Wooden clapboard	Asphalt shingle	Brick	Built 1868. Although altered this house represent the Italianate at this end of the neighborhood
88	Vernacular	Aluminum siding	Asphalt shingle	Stucco	Built 1924
89	Federal Colonial Revival	Shingled	Asphalt	Stucco	Built 1938, A very nice and intact late 1930s Colonial Revival
90	Duplex Ranch	Brick	Asphalt shingle	Unexposed	
91	Cottage	Aluminum siding	Asphalt shingle	Unexposed	Built 1930, a very simple vernacular cottage similar to those on John A. Woods
92	Ranch	Brick	Asphalt shingle	Unexposed	
93	Ranch- Prairie	Brick and Sandstone	Asphalt	Unexposed	
94	Townhouses	Brick	Asphalt shingle	Unexposed	
95	Greek Revival	Asbestos shingle	Asphalt shingle	Unexposed	Built ca. 1850, attractive example of a house changed by different 19th century architectural styles
96	Queen Anne	Wooden clapboards	Asphalt shingle	Stone	Built 1895, s fine, nearly intact example of a small Queen Anne
97	Vernacular	Asbestos shingle	Asphalt Shingle	Stucco	Built 1917, simple, well maintained vernacular house almost perfect match for 707 and 719
98	Vernacular	Brick	Asphalt shingle	Stucco	Built 1926, a simple well maintained vernacular house almost perfect match for 703 and 719
99	Vernacular	Aluminum siding	Asphalt shingle	Concrete block	Built 1929, a simple vernacular house almost a perfect match to 703 and 707
100	Italianate	Asphalt brick	Asphalt shingle	Brick	Built 1838, made Italianate 1865, began as a simple I-House and became an Italianate
101	Ranch	Brick	Asphalt shingle	Unexposed	
102	Colonial Revival	Wood shingle	Asphalt shingle	Unexposed	

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
103	Colonial Revival	Wood shingle	Asphalt shingle	Unexposed	Same as 1301 Pear but turned gable end to street
104	Colonial Revival	Vinyl siding	Asphalt shingle		Same as 1301 Pear but turned gable end to street and additional entry added to left side of gable end
105	Split-level Ranch		Asphalt shingle	Unexposed	
106	Ranch	Smooth concrete block	Asphalt shingle	Unexposed	
107	Cape Cod	Aluminum siding	Asphalt shingle	Unexposed	
108	Ranch	Concrete block	N/A	Unexposed	
109	Italianate	Wooden clapboard	Asphalt shingle	Unexposed	Built ca. 1875, a fine example of a simple Italianate
110	Modern Bungalow	N/A	N/A	Concrete block	Built ca. 1890, a simple house, altered and expanded
111	Ranch	N/A	N/A	Concrete block	
112	Vernacular	Aluminum siding	Asphalt shingle	Stucco	Built circa 1890, a simple house, altered and expanded
113	Bungalow	Wooden clapboards	Asphalt shingle	Concrete block	
114	Vernacular	Vinyl siding	Asphalt shingle	Stucco	Built 1892
115	Modern Ranch	Brick	Asphalt shingle	Unexposed	
116	Ranch	Brick	Asphalt shingle	Unexposed	
117	Ranch	Brick	Asphalt shingle	unexposed	
118	Ranch	Concrete block		unexposed	
119	Cape Cod	Wood clapboard	Asphalt shingle	unexposed	
120	Cape Cod	Aluminum siding	Asphalt shingle	unexposed	
121	Ranch Split Level			unexposed	
122	Ranch- small	Vinyl siding	Asphalt shingle	unexposed	
123	Ranch- small	Vinyl siding	Asphalt shingle	unexposed	
124	Cape Cod	Aluminum siding	Asphalt shingle	unexposed	
125	Ranch	Vinyl siding	Asphalt shingle	unexposed	
126	Carpenter Gothic	Aluminum siding	Asphalt shingle	Stucco	What remains of the original fabrics of this house is sparse. The double gable and general shape are all that hint at what it may have been.
127	Bungalow	Permastone and aluminum	Asphalt shingle	concrete block	
128	Cottage	Wooden shingles	Asphalt shingle	unexposed	This tiny cottage retains all of its original features and is representative of one of the many types of small workingman's home in the north side.
129	Greek Revival	Wood clapboard	Asphalt shingle	Stone	Historically significant
130	Greek Revival	Shingle	Asphalt shingle	Stone	This simple Greek Revival stands at the head of a line of five Green Revival houses and just past the Anson Brown house. This streetscape represents the earliest part of Ann Arbor history.

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
131	Greek Revival	Vinyl siding	Asphalt shingle	Stone	The first three houses in this series of five Greek Revivals at 1113, 1117, and 1123 were all built in the late 1830s and all appear on the 1854 plat map.
132	Greek Revival	New wooden clapboard	Asphalt	Stone	This house is fourth in a series of five Greek Revival houses that form a fine example of a mid-19th century streetscape.
133	Greek Revival	Vinyl siding	Asphalt	Stone	This simple Greek Revival opposite the series of five on the west side of Pontiac, adds to the streetscape. This house was built in 1850.
134	Greek Revival	Stucco	Asphalt shingle	unexposed	This is the last Greek Revival in a row of five on the west side of Pontiac. Estimated to be built in 1850s
135	Vernacular- Originally Greek Revival	Asbestos siding	Asphalt shingle	Stucco	This house used asbestos for exterior walls. Needs to be retrofitted. Take a picture of this house.
136	Vernacular	Asbestos shingle	Asphalt shingle	Stucco	A simple workers house
137	Greek Revival	Vinyl siding	Asbestos shingle	Stone	one and one half story building
138	Greek Revival	Vinyl siding	Asphalt shingle	Stucco	One of four Hen and Chick style Greek Revivals in the study area
139	International	Horizontal wood siding	Asphalt	concrete block	This house replaces a singularly graceful hen and chicks Greek Revival, taken to Greenfield Village and known as the Sinclair house or the Ann Arbor House.
140	Ranch- duplex	Brick	Asphalt	Unexposed	
141	Cottage	Shiplap siding	Asphalt shingle	Unexposed	
142	Vernacular	Wooden clapboards	Asphalt shingle	Stucco	A simple workers house moved here in 1947.
143	Ranch- duplex	Vertical siding	Asphalt	Concrete block	
144	Tudor Revival	Brick	Asphalt	Concrete block	
145	Greek Revival	Wooden clapboards	Asphalt shingle	Brick	Built in 1836, an intact and typical example of Greek Revival architecture
146	Chalet duplex	Concrete block and vertical wood siding	Asphalt	Concrete block	
147	Greek Revival	Stucco	Asphalt	Stucco	A spectacular example of large Greek Revival architecture, essentially intact which provides a "high style" example to the neighborhood.
148	Craftsman	Stucco	Asphalt	Concrete block	A fine example of the simple Craftsman style, with symmetrical façade, stucco walls, and half timbering in the gables.
149	chicken coop	Wooden clapboards	Asphalt shingle	Stucco	Converted to rental housing

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
150	Greek Revival	Shingle	Asphalt shingle	Stucco	This very nice shingled Greek Revival is representative of the mid-19th century. Built in 1853
151	Craftsman	1st/wooden clapboard, 2nd/shingle	Asphalt shingle	Stucco	Built in 1845, remodeled in 1912
152	Modern rustic	Vinyl siding	Asphalt shingle	Stucco	
153	Greek Revival	Wooden clapboards	Asphalt shingle	Stone	1½- story house built in 1855
154	Vernacular-gable front	Asbestos shingle	Asphalt shingle	Concrete block	In 1956 listed as under construction
155	Italianate	Wooden clapboards	Asphalt shingle	Stucco	Built in 1836, front addition in early 1870s, moved November 14, 1947
156	Federal Colonial Revival	Wide wood clapboard	Asphalt shingle	Stucco	An unaltered example of a 1930s Federal style house
157	New England Georgian	Stone with brick veneer	asphalt	Stone	Built in 1842, restored 1935–1940
158	Cottage	Asbestos shingle	Asphalt shingle	Stucco	Built in 1880
159	Cottage	Vinyl siding	Asphalt shingle	Stucco	Built in 1928
160	Dutch Colonial Revival	Aluminum siding	Asphalt shingle	Stucco	No history before 1945
161	Rustic Neo Modern	Vertical siding	Asphalt shingle	Cut stone blocks	Originally built in 1880
162	Cape Cod	Permastone	Asphalt shingle	Unexposed	
163	Vernacular	Vinyl siding	Asphalt shingle	Concrete block	Built in 1922, moved 1952, expanded later
164	Craftsman	1st/ wide wooden clapboard, 2nd/ narrow wooden clapboards	Asphalt shingle	Concrete block	Built in 1918, moved July 1946
165	Vernacular	Wooden clapboards	Asphalt shingle	Stone	Built 1886
166	Queen Anne	Wooden clapboards	Asphalt shingle	Concrete block	Built in 1891, moved July 1952
167	Vernacular	Asbestos shingle	Asphalt shingle	Stucco	Built in 1870, a simple gabled ell house.
168	Greek Revival	Wooden shingles	Asphalt shingle	Stucco	Built in 1855
169	Cottage	Board and batten	Asphalt shingle	Stucco	Built in 1926
170	Vernacular	Wooden clapboards	Asphalt shingle	Stucco	Built in 1875
171	Cape Cod	Vinyl siding	Asphalt shingle	Stucco	
172	Vernacular	Stone faced concrete	Asphalt shingle	Concrete block	Built in 1923
173	Bungalow	1st/ aluminum siding, 2nd/shingles	Asphalt shingle	Concrete block	Built in 1926
174	Carpenter Gothic	Stucco	Asphalt shingle	Stone	Built in 1840
175	Bungalow	Stucco	Asphalt shingle	Stucco	Built in 1920
176	Bungalow	Aluminum siding	Asphalt shingle	Concrete block	Built in 1930, moved in the late 1940s
177	Queen Anne	Asbestos shingle	Asphalt shingle	Stone blocks	Built in 1896
178	Cape Cod	Aluminum siding	Asphalt shingle	Stucco	1½- story Cape Cod house
179	Cape Cod	Aluminum siding	Asphalt shingle	Concrete block	Wrong photo here

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
180	Ranch	Vertical wood	Asphalt shingle	Concrete	
181	Cape Cod	Aluminum siding	Asphalt shingle	Unexposed	
182	Ranch	Vinyl siding	Asphalt shingle	Concrete block	
183	Greek Revival	Front/ aluminum siding, rest of house/ stucco	Asphalt shingle	Unexposed	Built 1860
184	Garrison Colonial Duplex	1st/brick, 2nd/vinyl	Asphalt shingle	Concrete block	
185	Cottage	Asbestos shingle	Asphalt shingle	Stucco	Built 1885
186	Greek Revival	Brick	Asphalt shingle	Brick	Built in 1841, sold as home in 1856
187	Vernacular	Wooden clapboards	Asphalt shingle	Stucco	Built 1866
188	Greek Revival	Vinyl siding	Asphalt shingle	Stone	Built 1845
189	Greek Revival	Wooden clapboards	Asphalt shingle	Stone	Built 1851
190	Greek Revival	Shingle	Asphalt shingle	Unexposed	Built 1840s
191	Greek Revival/ Craftsman	Brick and stucco	Asphalt shingle	Unexposed	Built 1851, remodeled 1900-20
192	Vernacular	Asphalt brick	Asphalt shingle	Brick	Built 1900
193	Greek Revival	Wooden clapboards	Asphalt shingle	Brick	Built 1860
194	Cottage	Shingle	Asphalt shingle	Brick	Built 1912
195	Colonial Revival	Vinyl siding	Asphalt shingle	Unexposed	Built 1934
196	Bungalow	Wooden clapboards	Asphalt shingle	Unexposed	Built 1930
197	Vernacular	Wooden clapboards	Asphalt shingle	Concrete block	Built 1933
198	Greek Revival Cottage	New shingle	Asphalt shingle	Unexposed	Built 1860
199	Colonial Revival	Shingle	Asphalt shingle	Concrete block	Built 1940
200	Unidentified		Asphalt shingle		
201	Modern Apartments	Board and batten	Asphalt shingle	Unexposed	
202	Modern Apartments	Board and batten	Asphalt shingle	Unexposed	
203	Modern Apartments	Vinyl siding	Asphalt shingle	Unexposed	
204	New House	Vinyl siding	Asphalt shingle	Unexposed	
205	Bungalow	Aluminum siding	Asphalt shingle	Stucco	Built 1926
206	Greek Revival	Aluminum siding	Asphalt shingle	Stone	Built 1855
207	Ranch	Vinyl siding	Asphalt shingle	Concrete block	
208	Raised Ranch	Board and batten	Asphalt shingle	Concrete block	
209	Raised Ranch	Vinyl siding	Asphalt shingle	Concrete block	
210	Vernacular	Vinyl siding	Asphalt shingle	Stone	Built 1870
211	Ranch	Brick	Asphalt shingle	Concrete block	
212	Vernacular	Aluminum siding	Asphalt shingle	Stone	Built 1890
213	Vernacular	Stucco	Asphalt shingle	Stucco	Built 1870
214	Vernacular	Wooden clapboards	Asphalt shingle	Stone	Built 1890
215	Bungalow	Wooden clapboards	Asphalt shingle	Concrete	Built 1926

No.[2]	Basic Style	Information on Materials (Walls)	Information on Materials (Roof)	Foundation	Notes (From Significance Statement)
				block	
216	Italianate	Wooden clapboards	Asphalt shingle	Stone	Built 1860
217	Ranch	Asbestos shingle	Asphalt shingle	Unexposed	
218	Ranch	Brick	Asphalt shingle	Unexposed	
219	Ranch	Brick	Asphalt shingle	Unexposed	
220	Vernacular	Aluminum siding	Asphalt shingle	Stone and brick	Built 1890
221	Vernacular	Aluminum siding	Asphalt shingle	Unexposed	Built 1921
222	Vernacular	Aluminum siding	Asphalt shingle	Stucco	Built 1918
223	American Four Square	Aluminum siding	Asphalt shingle	Concrete block	Built 1926
224	Bungalow	Aluminum siding	Asphalt shingle	Concrete block	Built 1924
225	Craftsman	1st/clapboard, 2nd/shingles	Asphalt shingle	Stucco	Built 1924
226	Greek Revival	Asbestos shingle	Asphalt shingle	Unexposed	Built 1845
227	Ranch	Brick	Asphalt shingle	Unexposed	
228	Cottage	Asbestos shingle	Asphalt shingle	Stucco	Built 1838
229	Greek Revival	Vinyl siding	Asphalt shingle	Stucco	Built 1850
230	Colonial Revival	1st/clapboard, 2nd/shingles	Asphalt shingle	Stucco	Built 1929

Note: The original data source of this Appendix is "Ann Arbor Intensive Survey" completed by the Michigan State Historic Preservation Office in 1996.

Appendix E: Analysis of Size of Homes in Ann Arbor and Grand Rapids

Table 22. Analysis of Size of Homes in Ann Arbor

Eras	% of Homes Among Housing Stock			Home Size (ft^2)				
	Percentage in Census	Total number at Zillow.com 9/18/2012	Total number studied	Minimum	25 percentile	Median	75 percentile	Maximum
1800–1929	20.4	613	71	734	1,456	1,805	2,065	4,239
1930–1949		335	31	840	1,144	1,500	1,980	3,695
1950–1969	34.1	1,007	60	832	1,267	1,684	2,297	4,034
1970–1979	18.9	186	40	1,352	1,983	2,577	3,275	4,926
1980–1999	21.0	193	33	1,352	1,983	2,577	3,275	8,162
2000–2012	5.6	109	30	648	1,830	2,622	3,490	3,836
Total	100.0	2,026	265	648	1,400	1,849	2,436	8,162

Source: Ann Arbor homes available at www.zillow.com on 9/18/2012

Key findings:
- Homes available in Zillow.com offered valuable samples of current housing stock in a local market
- Houses in this list were categorized into six groups corresponding to the construction eras.
- The size of individual houses was larger, but a greater number of smaller houses were built after the energy code was implemented in Michigan.
- In terms of house forms, most homes built before 1930 were multistory block forms, homes built between 1930 and 1949 were one a half- or two- story block forms. Many houses in this period were 1½-story Cape Cods which were simple block house forms. A majority of homes built between 1950 and 1979 were one-story ranches or split-level ranches. The forms became more complex for houses built between 1980 and 1999. The house size became larger for this period. Houses built after 2000 became smaller and returned to simple forms. A majority of houses built after 2000 had multiple stories and simple block forms, and many of them had multiple stories and complex forms.

Suggestions:
- The most reasonable targets for energy-efficient retrofit are houses built before 1949 that have two -stories and have vertically oriented block forms, which were referred to as "charmers" in this study.
- The next reasonable targets for energy-efficient retrofit are one-story ranch homes with basement built between 1950 and 1979 that can be defined as the simple block form.

Table 23. Analysis of Size of Homes in Grand Rapids

| Eras | % of Homes Among Housing Stock | | | Home Size (ft^2) | | | | |
	Percentage in Census	Total number at Zillow.com 9/18/2012	Total number studied	Minimum	25 percentile	Median	75 percentile	Maximum
1800–1929	48.1	3,467	77	834	1,255	1,472	1,769	3,602
1930–1949		1,039	30	1,000	1,405	1,603	1,853	2,236
1950–1969	27.1	1,743	35	800	1,160	1,450	1,890	3,263
1970–1979	7.8	324	30	1,128	1,380	1,800	2,244	4,005
1980–1999	13.1	465	30	1,012	1,680	2,101	2,500	3,369
2000–2012	3.9	292	30	1,031	1,970	2,424	3,403	5,484
Total	100.0	9,322	292	800	1,328	1,642	2,065	5,484

Source: Grand Rapids homes available at www.zillow.com on 9/18/2012

Key findings:

- Homes available in Zillow.com offered valuable samples of current housing stock in a local market

- Houses in this list were categorized into six groups corresponding to the construction eras.

- The size of individual houses was larger, but a greater number of smaller houses were built after the energy code was implemented in Michigan similar to Ann Arbor.

- In terms of house forms, most homes built before 1930 were multistory block forms; homes built between 1930 and 1949 were 1 or 1½-story block forms. More one-story homes were observed in Grand Rapids than Ann Arbor. Many houses in this period were 1½-story Cape Cods, which were simple block house forms. A majority of homes built between 1950 and 1979 were one-story ranches or split-level ranches. The forms became more complex for houses built between 1980 and 1999, but still more homes with block forms were observed. The house size became larger and forms became more complex in this period. However, houses built after 2000 included a lot of smaller homes with simple forms. While a majority of houses built after 2000 had multiple stories and simple block forms in Ann Arbor, many homes in Grand Rapids still showed complex forms and had multiple stories.

Suggestions:

- The most reasonable targets for energy-efficient retrofit are houses built before 1949 that have 1 or 1½-story homes, which are referred to as Cape Cod style or two-story homes that have vertically oriented block forms.

- The next reasonable targets for energy efficient retrofit are one-story ranch homes with basement built between 1950 and 1979 that can be defined as the simple block form.

Appendix F: Profile of U.S. Housing Stock Overall, by Region

Table 24. Profile of U.S. Housing Stock Overall, by Region

Housing Characteristic	United States		Region							
	Overall		Northeast		Midwest		South		West	
	Number	%	Number	%	Number	%	Number	%	Number	%
All Units Surveyed (Unweighted)	73,222	100.0	15,726	21.50	17,979	24.60	25,913	35.40	13,604	18.60
All Units (Weighted)	130,111,607	100.0	23,316,060	17.90	29,403,380	22.60	49,371,526	37.90	28,020,641	21.50
Type										
One-Unit Building, Detached From Any Other Building	83,515,810	63.40	12,810,931	54.94	20,187,732	68.66	31,762,797	64.33	17,754,350	63.36
One-Unit Building, Attached to One or More Buildings	7,049,191	5.40	2,055,429	8.82	1,215,931	4.14	2,379,382	4.82	1,398,449	4.99
Building With Two or More Apartments	31,809,122	24.40	7,791,443	33.42	6,495,561	22.09	10,212,981	20.69	7,309,037	26.08
Manufactured (Mobile) Home	8,737,484	6.70	658,257	2.82	1,504,056	5.12	5,016,367	10.16	1,558,805	5.56
(Single-Family Homes Only)	82,423,738		12,799,015		20,186,331		31,736,229		17,702,163	
Year House is Built										
Built Before 1929	9,191,485	11.20	2,797,367	21.86	3,626,678	17.97	1,643,565	5.18	1,123,875	6.35
Built 1930–1949	10,033,534	12.20	1,846,493	14.43	2,729,376	13.52	3,307,077	10.42	2,150,588	12.15
Built 1950–1969	21,109,643	25.60	3,718,876	29.06	5,378,652	26.65	7,638,185	24.07	4,373,930	24.71
Built After 1970	42,089,076	51.10	4,436,279	34.66	8,451,625	41.87	19,147,402	60.33	10,053,770	56.79
Number of Stories										
One	36,296,100	44.00	1,229,374	9.61	4,200,919	20.81	20,587,085	64.87	10,278,722	58.06
Two	27,777,668	33.70	462,946	3.62	8,746,565	43.33	8,442,245	26.60	5,945,912	33.59
Three or More	18,349,970	22.30	6,926,695	54.12	7,238,846	35.86	2,706,899	8.53	1,477,530	8.35
Size										
≤ 900 ft^2	5,591,632	7.20	879,221	6.87	1,563,594	7.75	1,952,735	6.15	1,196,082	6.76
> 900 and ≤ 2,500 ft^2	55,117,416	71.00	7,454,126	58.24	13,042,244	64.61	22,074,967	69.56	12,546,079	70.87
> 2,500 ft^2	16,929,810	21.80	2,985,005	23.32	4,151,263	20.56	6,410,587	20.20	3,382,955	19.11

Source: AHS (U.S. Census Bureau 2009). www.census.gov/housing/ahs/data/microdata.html

Appendix G: Multiple and Logistic Regression Models To Show Relationships Between Monthly Energy Bill and Housing Variables

Table 25. Multiple Regression Model (Midwest Only)

Multiple Regression Model		R-Square	Adjusted R-Square	Sig.	
Overall		0.184	0.182	.000a	
Predictor Variables		Beta Coefficient	Beta Coefficient	T-Value	Sig.
Constant		40.841		7.695	0.000
SteamD	Steam system used as supplemental heating equipment	90.461	0.030	2.851	0.004
HEQUIP2	Main Heating System: Steam or hot water system with radiators OR other system using steam or hot water	14.965	0.034	3.214	0.001
HEQUIP3	Main Heating System: Electric heat pump	-26.104	-0.042	-3.902	0.000
HEQUIP4	Main Heating System: Built-in electric baseboard heating or electric coils in floors, ceilings, or walls	-24.462	-0.036	-3.405	0.001
HEQUIP9	Main Heating System: Wood burning stove, pot belly stove, Franklin stove	-64.008	-0.051	-4.865	0.000
Rooms	Number of rooms in unit	16.837	0.277	21.440	0.000
Per	Number of persons in household	12.345	0.176	15.808	0.000
Built1D	House built in 1929 or earlier	23.706	0.086	7.008	0.000
Built2D	House built between 1930 and 1949	29.012	0.096	8.176	0.000
Built3D	House built between 1950 and 1969	17.097	0.077	6.394	0.000
Stories	Number of Stories in house	10.991	0.080	5.448	0.000
Unitsf1000	Square footage of unit divided by 1000	1.603	0.036	3.271	0.001
hhincome80	Household income in the 80% highest level	-7.592	-0.031	-2.895	0.004
Fplwk	Unit has usable fireplace	-11.482	-0.057	-4.795	0.000
FullB	With a basement under all of the house	-10.789	-0.053	-3.293	0.001
PartB	With a basement under part of the house	-14.114	-0.055	-3.584	0.000

Source: AHS (U.S. Census Bureau 2009). www.census.gov/housing/ahs/data/microdata.html

Table 26. Logistic Regression Model (Midwest Only)

Logistic Regression Model		Cox and Snell R-Square	Nagelkerke R-Square	–2 Log Likelihood	
Overall		0.484	0.717	3426.551	
Predictor Variables		Beta Coefficient	Exp (B) Coefficient	Wald	Sig.
Constant		−16.391		1181.691	0.000
HEQUIP2	Main Heating System: Steam or hot water system with radiators OR other system using steam or hot water	0.619	1.858	11.727	0.001
rooms	Number of rooms in unit	0.306	1.358	81.230	0.000
Stories	Number of Stories in house	3.244	25.646	791.999	0.000
unitsf1000	Square footage of unit divided by 1000	1.016	2.763	352.870	0.000
zinc1000	household income divided by 1000	0.002	1.002	6.878	0.009
Built1D	House built in 1929 or earlier	4.336	76.428	790.479	0.000
Built3D	House built between 1950 and 1969	1.149	3.154	97.842	0.000
FullB	With a basement under all of the house	0.212	2.662	21.240	0.000
PartB	With a basement under part of the house	0.686	1.985	9.465	0.002
fplwkD	Unit has usable fireplace	0.449	1.566	18.760	0.000

Dependent Variable - LRMEB: 1- type of houses whose overall MEB ranks in the top 25% group; 0 - types of houses whose overall MEB does not rank in the top 25% group.
Note: The top 25% OMEB group of houses consumes about 31.51% of the total overall MEB of all types of houses.

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