

# **Economic Benefits and Environmental Sustainability from Low-income Green Home Development in Michigan**

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# **Economic Benefits and Environmental Sustainability from Low-income Green Home Development in Michigan**

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## Executive Summary

### Background

The number of LEED-certified homes has increased tremendously over the past few years. The affordable housing sector has played an important role in this green movement by building about 34% of all LEED-certified homes. Habitat for Humanity also contributed to this increasing number of affordable green homes. Although there is a consensus in the industry that a LEED-certified home does provide healthier, more comfortable, more satisfying residential environment, little is known about the actual performance of LEED-certified homes. In order to identify the benefits and shortcomings of green home programs, it is critical to evaluate the actual performance of LEED-certified homes.

### Research Purpose

The present project conducted a Post-Occupancy Evaluation for LEED-certified homes focusing on LEED-certified Habitat for Humanity to (1) identify the actual performance of LEED-certified affordable homes in terms of residential satisfaction, energy efficiency, indoor environmental quality, architectural design, health impact, and environmental attitudes and behaviors, and (2) to provide feedback for future affordable green home projects.

### Research Methods

Two methodological approaches were used for this study. Qualitative case studies were conducted with 15 LEED-certified Habitat for Humanity residents in Kent County, Michigan through in-depth interviews, observations, and IEQ measurement. Next, a quantitative survey was administered to residents of LEED-certified homes in Midwest in collaboration with the Alliance for Environmental Sustainability (AES) and the Office for the Survey Research at Michigan State University. A total of 605 surveys was sent out and 235 were collected, yielding a 38.8% response rate.

### Findings: Case studies with LEED-certified Habitat for Humanity in Michigan

- **Residential Satisfaction:** LEED-certified Habitat for Humanity residents in the case studies were very satisfied with their green home although some residents indicated lower satisfaction with their neighbors and the safety of their neighborhood. All participants reported that their homes were sustainable and healthy.
- **Quality of life:** Most participants agreed that since moving into their current homes they have experienced improved family relations, better health conditions, a more positive attitude and performance of children, and more confidence in their life. Most participants indicated they had good or excellent physical health, emotional status, life enjoyment, and quality of life.
- **Indoor Environmental Quality (IEQ):** Most participants were very satisfied with the thermal condition in the winter due to efficient HVAC systems and good insulation while many participants complained about the absence of central air conditioning. Most of the participants were very happy with the amount of natural light and the quality of electrical lighting although several respondents wished that their homes had more windows. The

majority of participants were happy with the amount of cross-ventilation and good performance of the air exchanger. Several respondents did not use their air exchanger because it brought cold air into the space during the winter and consumed more energy. Participants were relatively pleased with humidity and acoustic condition of their homes.

- **Interior Space:** The majority of participants were satisfied with space layout and size. Several respondents wanted to have more amenities for people with disabilities, to avoid making bedrooms too tiny, to use more easily maintained finishes, and to have more supervision during the construction to reduce defects in the building.
- **Energy Efficiency:** Most participants indicated they had electricity and natural gas bills that were 30-50% lower. Some of them reported that they had not noticed any savings on their energy bills, reflecting the importance of resident life style on energy saving. All participants were very satisfied with energy efficiency for water, electricity, and natural gas.
- **Health Impact:** Participants revealed some positive effects of their home on the condition of their health. All respondents who lived with people who had asthma noticed that their symptoms had subsided; those with allergies did not show much improvement. Overall, participants perceived their homes as healthy and their health as better.
- **Environmental Attitude and Behavior:** Only two participants out of 15 indicated their increased awareness of environmental issues since moved into their LEED-certified home while most of the participants were not interested in environmental issues outside of saving energy. The major change in their environmental behaviors was their efforts at recycling because of its ease and because of the credits given to them.
- **Informed about LEED:** More than half of participants could not remember if they had received information about LEED. Only two described themselves as well informed.

#### **Findings:** Survey with LEED-certified Homes in the Midwest

- **Satisfaction with home environment:** More than 90% of respondents were satisfied with their LEED-certified home environment. The satisfaction with neighborhood environment was also high, yet lower than satisfaction with home environment. Respondents of Habitat for Humanity homes showed more satisfaction with their home environment than did residents of non-Habitat homes. Respondents were more satisfied with the amount of daylight and quality of artificial light, and space layout than they were with neighborhood cleanliness, acoustic quality, outside views, and humidity. Residents of Non-Habitat for Humanity homes were more pleased with all specific aspects of home environment than were residents of Habitat for Humanity homes. Survey respondents perceived air quality, daylight, and temperature as more important factors in their overall satisfaction than furniture/finishes and acoustic quality.
- **Quality of life:** Nearly half of respondents indicated their mental/emotional state, enjoyment of life, and quality of life are excellent in their LEED-certified homes. More than 80% of respondents agreed that their living conditions and overall quality of life have improved since becoming residents of LEED-certified homes although they agreed less that they had become more engaged with neighbors and that their children's school performance had improved. Residents in the Habitat for Humanity perceived more strongly that their quality of life has improved than did members of the non-Habitat group.

- **Occupant comfort:** Nearly 90% of respondents described their indoor air as fresh. About 70% perceived their acoustic quality as quiet. More than half of respondents found their humidity, temperature, lighting to be appropriate. More than 90% of respondents thought their home was comfortable, attractive, safe, pleasant, and sustainable. Overall, occupants' perceived emotional comfort was more positive than their physical comfort.
- **Family well-being:** The perceived effectiveness of the indoor environment on respiratory symptoms was neutral. Among the factors that affect respiratory symptoms, air quality was the most influential, followed by carpet/floors, humidity, and temperature.
- **Energy efficiency:** Nearly 90% of survey participants considered the energy performance of their home as efficient and about half rated their home as extremely energy efficient. Respondents were satisfied with efficiency of water, electricity, and gas usage. The satisfaction with efficient low-flow toilets, electrical lighting, faucets, and hot water supply was high, whereas satisfaction with wind power, solar energy, and windows and doors was low. Satisfaction with their energy efficiency differed depending on home ownership, LEED rating, and whether the home was built by Habitat for Humanity or not. Those who rented homes, those in 'certified' LEED homes, and those in the non-Habitat group are more likely to be dissatisfied with energy efficiency. Home owners, those in higher-rated LEED homes, and those in Non-Habitat group considered themselves well informed about the operation of energy efficient features.
- **Pro-environmental behavior:** About 12% of survey respondents attended LEED classes, and about 18% were members of conservation groups. The attendance rate in LEED classes was higher in the Habitat group, while the conservation group membership was lower. Likelihood of pro-environmental activity depended on the types of behaviors and household characteristics. Home owners are more likely to use Energy Star appliances, to buy a LEED/green home for their next house, and to use recycled materials than are those who rent homes. As the LEED certification rating rises from certified to platinum, so does the likelihood of using environmentally friendly chemicals. Finally, those in the Habitat group are less likely to buy organic food and less likely to avoid environmentally irresponsible companies.

## Conclusions & Recommendations

The findings of this study revealed that most residents of LEED-certified home were satisfied with their home environment and their quality of life in their home. Residents in the Habitat for Humanity, in particular, were more satisfied with their homes and their quality of life than Non-Habitat residents. Residents in the Habitat for Humanity tended to perceived more strongly that their quality of life has improved than did members of the non-Habitat group. They were also more satisfied with energy efficiency of their home than Non-Habitat residents.

- **Promote sustainability in low-income housing:** Major findings strongly support the positive effects of green low-income homes on residents' behavioral, social, and psychological aspects of well-being. Stronger support and considerations should thus be added to developing more numbers of green Habitat for Humanity homes. Policy makers should

understand this necessity and promote incentives or financial support for green low-income home development and supply.

- **Improve the design of low-income green housing.** Although the houses were LEED-certified, some problems in maintaining the green features, building performance, and comfortable home environment were identified. Architects, designers, engineers, green policy makers, and Habitat for Humanity Affiliates should consider the specific needs relevant to these issues to improve the design quality of low-income green home through the process of planning, design, and construction.
- **Promote the POE:** Further implementation of POEs is exceptionally important to verify actual performance and expected performance. The finding that many residents did not remember the LEED certification level of their homes proved that post-occupancy follow-ups should be planned for the LEED-certified or other types of green homes.
- **Contribute to the general body of knowledge:** The finding from this POE study increased understanding of the benefits to be gained from LEED-certified low-income homes by applying empirically tested, research-based knowledge. This project provided empirical data from both intensive interviews and surveys and offered fundamental tools for POEs for future studies.
- **Promote public awareness:** This POE study will educate the public about the impact of LEED-certified homes on (1) improving the residential environmental quality and energy efficiency, (2) reducing residents' health risks and (3) enhancing residents' comfort and satisfaction by disseminating the results of this research at conferences and by publishing articles in scholarly and extension journals.
- **Make a Policy Recommendation:** Policy makers will compile a list of policy recommendations this research proposed to make Michigan more sustainable and profitable through greater economic and environmental benefits of low-income green homes by promoting more widespread adoption of green homes.
  - 1) Incentives for green homes, such as LEED-certified homes, Energy Star Homes, or National Association of Home Builders' Green certified homes, should be offered to developers, contractors, and homeowners.
  - 2) Policy makers should collaborate closely with local builders and developers to apply more green home features to new or existing low-income houses.
  - 3) Post-occupancy evaluations of green certified homes should be encouraged, particularly for low-income housing. Continuous efforts should be made to save energy and keep green homes energy-efficient for these households and homeowners.
  - 4) We suggest conducting POEs of green certified homes in five or ten years to preserve their green features and energy efficiency.
  - 5) We suggest offering regular educational seminars for residents of green certified homes in order to offer precise information about the green features of their homes and educate them how to keep their homes green.
  - 6) In addition, incentives should be considered for upgrading low-income housing to make it more energy-efficient and environmentally friendly.



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# BACKGROUND

## LEED for Homes

Green building performance is generally evaluated objectively through the use of green building certification programs. The U.S. Green Building Council’s (USGBC) Leadership in Energy and Environmental Design (LEED) is one of the leading green building certification programs in the United States. Based on the evaluation of a series of categories, LEED awards a LEED certification level to each project: Certified, Silver, Gold, or Platinum.

The number of green homes that have received LEED certification in the U.S. and Canada has rapidly increased during the past few years. In March 2010 the USGBC reported 2,889 LEED-certified home projects (5,000 homes) in the U.S. and Canada. According to the USGBC report of April 2012 the number of LEED-certified homes jumped to 7,567 projects (19,357 homes): 1,177 projects (1,310 homes) awarded ‘Certified’; 3,298 projects (7,248 homes) ‘Silver’; 1,705 projects (5,545 homes) ‘Gold’; and 1,387 projects (5,264 homes) ‘Platinum’ (See Table 0-1). The USGBC reports indicate that the number of LEED-certified homes increased about two and a half times in two years, a number which is expected to increase continuously.

The affordable housing sector has been an important part of the green movement. The ever-increasing number of LEED-certified homes today is largely credited to the affordable housing sector. About 34% (2,540 projects) of LEED-certified homes in April 2012 were affordable housing projects (USGBC, 2012), a significant portion of which, were built through the efforts of Habitat for Humanity.

**Table 0 - 1. Increased Number of LEED-certified Home**

Ratings	March 2010		April 2012	
	No. of Projects	No. of Homes	No. of Projects	No. of Homes
Certified	380	490	1,177	1,310
Silver	1,621	2,470	3,298	7,248
Gold	530	1,328	1,705	5,545
Platinum	358	712	1,387	5,264
<b>Total</b>	<b>2,889</b>	<b>5,000</b>	<b>7,567</b>	<b>19,357</b>

## LEED-certified Habitat for Humanity

Habitat for Humanity, a non-profit housing ministry, builds simple, decent, and affordable homes in partnership with low-income families by using volunteer labor, discounted or donated materials, and home buyer sweat equity. The homes are sold at cost with very low or no-interest mortgages. Recently, Habitat for Humanity International stated that its aim is to bring green housing to all income levels by way of a \$30 million grant program through a partnership with The Home Depot Foundation (Habitat for Humanity, 2009). As

of April 2012 there were 676 LEED-certified Habitat for Humanity homes in the U.S. (USGBC, 2012). This program called “Partners in Sustainable Building,” will allow Habitat affiliates in 45 states to build 5,000 LEED- and Energy Star-certified homes in the near future.

Starting in 2010, all Michigan affiliates pledged to build to at least minimum Energy Star standards, while many are building to green building program standards (Habitat for Humanity of Michigan, 2011). As of April 2012, 172 home projects (340 homes) received LEED certification to varying degrees in Michigan (see USGBC, 2012): 12 homes designated as Certified; 64 (116 homes) Silver; 66 (108 homes) Gold; and 30 projects (99 homes) Platinum. Of these, 92 homes were built by Habitat for Humanity: 1 Certified, 52 Silver, 35 Gold, and 4 Platinum.

Habitat for Humanity of Kent County built most of the LEED-certified Habitat homes in Michigan by completing 85 LEED-certified Habitat for Humanity homes out of 92, based on the LEED for Home report provided by USGBC in 2012. According to Alliance for Environmental Sustainability (2012), the Midwest regional LEED for Home provider, Kent County affiliates found that the extra cost per Habitat house to incorporate green building technologies and a no-step entry is approximately \$8,000. This amount can vary by affiliates and be relative to the current standards and practices, but the long-term benefits to the homebuyer and the environment were found to definitely justify that extra cost. Annual savings from electricity, water, and heating alone were estimated to be at least \$1,000 per home.

### **Post Occupancy Evaluation (POE) of LEED-certified Homes**

Post-Occupancy Evaluation (POE) is “the process of evaluating building[s] in a systematic and rigorous manner after they have been built and occupied for some time” (Preiser, Rabinowitz, & White, 1988). Post-Occupancy Evaluations (POEs) are essential to determine whether buildings and technologies function as intended, how well the buildings match user needs, and how building design, performance, and fitness for each building’s purpose can be improved.

Post-Occupancy Evaluation (POE) is important for green building because it helps the designers, architects, builders, and policymakers understand how to obtain the desired results of green building features. However, although sustainability is now becoming an industry-wide priority, Post-Occupancy Evaluation (POE) remains still significantly underutilized for the residential sector. Although there is a general agreement in the industry that a LEED-certified home does provide a healthier and comfortable housing environment to its occupants in addition to generating energy efficiency, little is known about the extent to which such a home actually reduces human health risks and improves comfort, satisfaction, and quality of life while in use.

The evaluation of the actual performance of green homes has been overlooked, and particularly little data is currently available about Post-Occupancy effects of LEED-certified

Habitat for Humanity homes on residents. It is thus absolutely critical to validate those actual precise benefits of LEED-certified homes, as that certification relates to building performance and occupants' health, comfort, and satisfaction. Such evaluation is a key for providing evidence-based policy direction to enhance economic and environmental benefits of green practices.

Thanks to the Michigan Applied Public Policy Research (MAPPR) Grant from the Institute for Public Policy and Social Research (IPPSR) at Michigan State University, the present project therefore conducted a Post-Occupancy Evaluation (POE) of LEED-certified homes, focusing on LEED-certified Habitat for Humanity homes in Michigan to identify their actual performance for residents and also the benefits and shortcomings of the current LEED for Home certification system.

## STUDY PURPOSE AND OBJECTIVES

The main goal of the proposed POE project was to offer a thorough policy recommendation for policymakers and thus effectively enhance economic and environmental benefits of green homes through evaluating and promoting the sustainability of low-income housing in Michigan. To achieve this primary purpose, this project strove to accomplish four specific research objectives.

First, this research aimed to identify actual building performance and environmental outcomes of LEED-certified low-income green homes, including energy efficiency, indoor environmental quality, and occupants' health, comfort, satisfaction, and quality of life. Second, this research aimed to examine occupant perceptions and opinions of the LEED-certified low-income green homes. Third, this POE study investigated additional opinions from the LEED-certified house occupants in general and determined occupants' concerns about and perceptions of energy-efficient green homes. The results from this specific investigation targeting LEED-certified housing occupants in general were expected to provide socially equitable policy implications for energy-efficient green home development for low-income households. Fourth, this POE study aimed to promote further adoption of green homes for low-income households and increase public awareness about the benefits of LEED-certified green homes. This POE project will provide research-based knowledge for articulating practical policy implications relevant to energy-efficient green home development for low-income households in Michigan.

## METHODS

The present project employed two methodological approaches as follows:

### Part I. Qualitative research unitizing case studies:

We conducted case studies with 15 households living in LEED-certified Habitat for Humanity homes (12 LEED Silver and 3 LEED Gold) in Kent County, Michigan. To examine the physical characteristics and performance of LEED-certified Habitat for Humanity homes, observations of home and neighborhood environments were conducted first, and indoor environmental quality (IEQ) was measured using IEQ monitoring kits for each selected case study home. To identify resident perceptions about the performance of their LEED-certified Habitat for Humanity homes, this project conducted in-depth interviews with the residents using a structured interview protocol and a standardized questionnaire (see Table 0-2).

Participants were recruited between May and June 2011, and interviews were conducted between June and August 2011. The interview questionnaire was reviewed and approved by the Institutional Review Board of the Human Subject Protection Program at Michigan State University in May 2011. Each interview was conducted at participants' homes for 60 to 90 minutes. Participant characteristics are presented in the Part I result section.

**Table 0 - 2. Data Collection Method for Case Studies**

Objectives	Contents	Data Sources
To examine the physical characteristics and performance of LEED-certified Habitat for Humanity	<ul style="list-style-type: none"> <li>• Take photos</li> <li>• Initial observations of home environments</li> </ul>	<u>Initial site visits</u> <ul style="list-style-type: none"> <li>• Initial resident contacts</li> </ul>
	<ul style="list-style-type: none"> <li>• In-depth observations of home environments</li> <li>• Measurement of indoor environmental quality</li> </ul>	<u>Second visit</u> <ul style="list-style-type: none"> <li>• Measurement of home environments</li> <li>• Interviews with residents</li> </ul>
To identify resident perception about the performance of their LEED-certified Habitat for Humanity	<ul style="list-style-type: none"> <li>• Residents' opinions on satisfactions and problems</li> </ul>	

## **Part II. Quantitative research utilizing surveys:**

To evaluate the performances of general LEED-certified homes in relation to LEED-certified Habitat for Humanity homes, a survey was conducted for LEED-certified homes in the U.S. The study sample was drawn from households living in LEED-certified homes in the Midwest including in Michigan, Minnesota, Missouri, Ohio, Illinois, and Indiana.

The survey was conducted through collaboration with the Alliance for Environmental sustainability (AES) and the Office for Survey Research at Michigan State University. The survey questionnaire was reviewed and approved by the Institutional Review Board of the Human Subject Protection Program at Michigan State University in May 2011. Participants were recruited between October and November 2011 through information letters sent to the survey targets, and mail-in surveys were conducted from January through March 2012. We sent out a total of 605 surveys to the sample, and 235 were collected. The response rate was 38.8%. The survey participants' characteristics and houses' characteristics are presented in the Part II result section.

The survey questionnaire for the present study was developed to gather and analyze a broad range of user feedback for the performance of green homes based on (1) the Occupant Satisfaction Survey tool provided by the Center for the Built Environment (CBE) at the University of California at Berkley, (2) the AUDE Guide to -Occupancy Evaluation, and (3) the Survey tool by the Center for Sustainable Building Research, College of Architecture and Landscape Architecture, University of Minnesota. The survey consisted of various categories including (1) the LEED-certified home in general, (2) satisfaction about the home in general and various aspects of the indoor environment, (3) overall wellbeing including the health impact, (4) energy efficiency and building performance, (5) the environmental behavior of residents, and (6) demographics.

## PART I RESULTS FROM INTERVIEW

This part presents the results of the qualitative research utilizing case studies. Fifteen LEED-certified Habitat for Humanity residents participated in this study. The results consist of:

- I-1. Interview participants
- I-2. Overall satisfaction & quality of life
- I-3. Resident perception about indoor environmental quality (IEQ)
- I-4. Interior space planning, furnishings, and finishes
- I-5. Energy efficiency
- I-6. Perceived health impact
- I-7. Environmental attitude & behavior
- I-8. Informed about LEED

### I-1 INTERVIEW PARTICIPANTS

This section presents demographic and socioeconomic characteristics of the participating households and housing characteristics of the subject homes for this study. Please note that any respondent who did not provide demographic information was not included in this report, although all respondents agreed to participate in the interview.

Table I-1 shows demographic information of the respondents. The group consisted of 4 males and 11 females. The ages of the respondents ranged from 20 years to 60 and older. About half of the respondents reported themselves as Black or African-American (50.0%), followed by White (28.6%), other (14.3%), and Asian (7.1%). Nine respondents were currently employed, and 4 were unemployed. About half of the respondents identified their education level as having completed high school (53.8%). About 30.8% completed college, 7.7% completed grade school, and about 7.7% had no formal education. A majority of respondents' income ranged from "less than \$20,000" to "not more than \$40,000" (92.9%). None of the interview respondents was a member of any environmental conservation group.

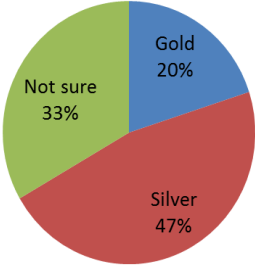
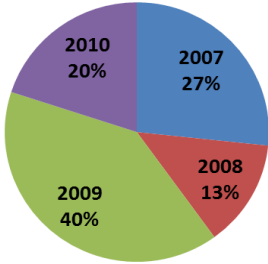
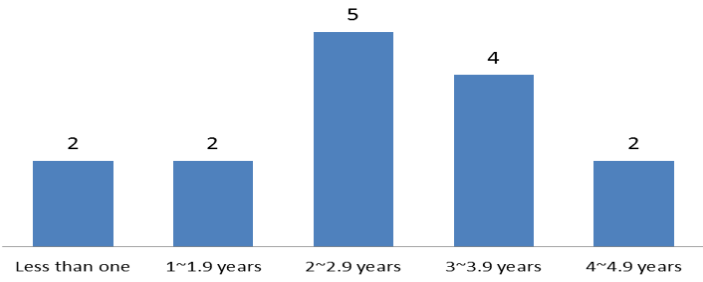
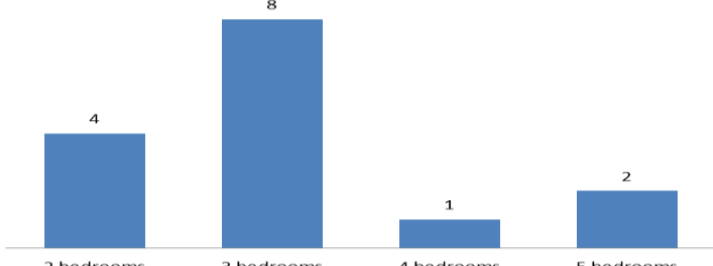
**Table I - 1. Interview Participants' Demographics**

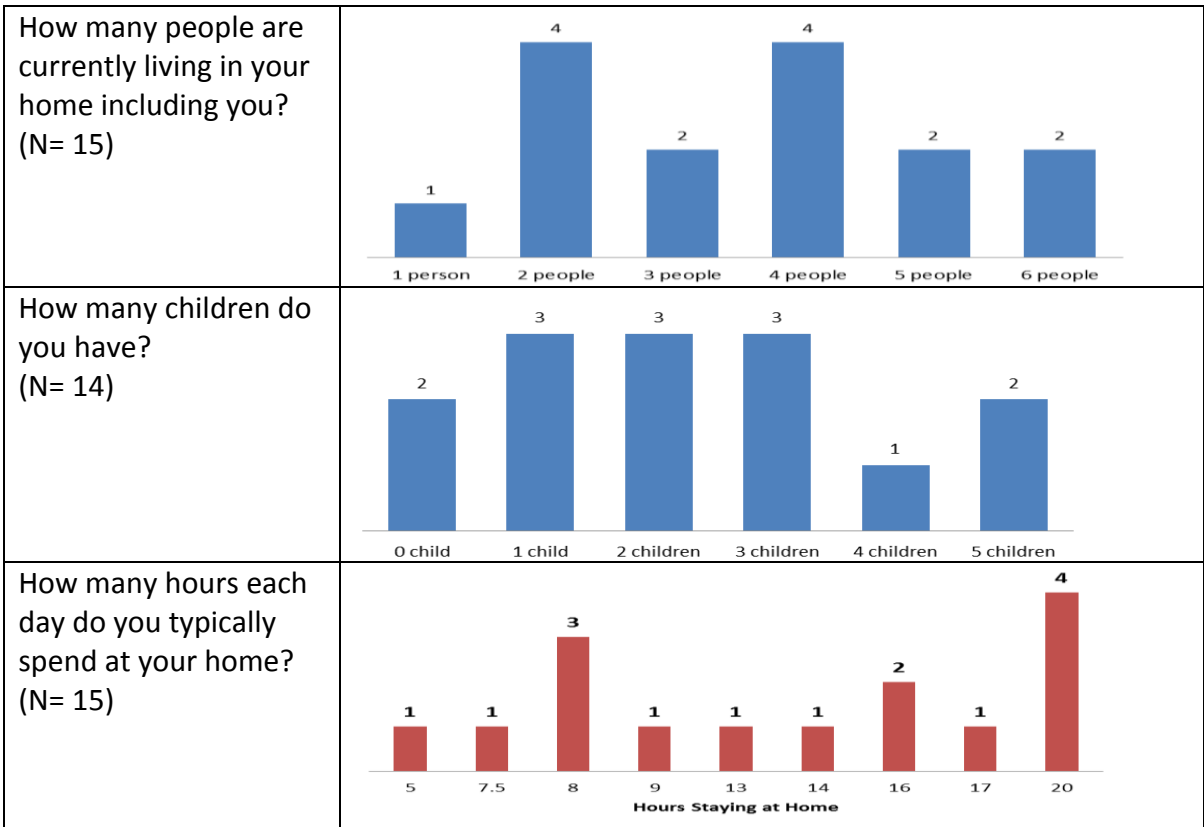
<b>Demographics</b>	<b>No. of respondents</b>	<b>Percent</b>
<b>Age (N=14)</b>		
29 years or younger	1	7.1
30-39	5	35.7
40-49	4	28.6
50-59	3	21.4
60 years or older	1	7.1
<b>Gender (N=15)</b>		
Male	4	28.6
Female	11	71.4
<b>Race (N=14)</b>		
White	4	28.6
Black or African-American	7	50.0
Asian	1	7.1
Other (Mexican, Mixed)	2	14.3
<b>Employment Status (N=13)</b>		
Employed	9	69.2
Other (Disabled, Social security, Term)	4	30.8
<b>Education Level (N=13)</b>		
No formal education	1	7.7
Completed grade school	1	7.7
Completed high school	7	53.8
Completed college	4	30.8
<b>Household Income (N=14)</b>		
Less than \$20,000	4	28.6
\$20,000 to \$39,999	9	64.3
\$40,000 to \$59,999	1	7.1
<b>Membership of Environmental Conservation Group (N=13)</b>		
Yes	0	0
No	13	100



Housing characteristics of the LEED-certified homes for this case study are presented in Table I-2. Out of 15 homes, 12 were Silver certified and 3 were Gold certified. However, the homeowners of the 5 Silver homes did not clearly remember their certification level. All 15 homes were built after 2007 and thus were not older than 5 years. The lengths of residence in the houses were consistent with the ages of their homes. Out of 15 homes, 8 homes were 3-bedroom units, and 4 homes were 2-bedroom units. Three homes were 4- or 5-bedroom units. The number of family members in the houses ranged from 1 to 6. Many households had multiple children living in the house. The numbers of hours the interview participants spent daily at home ranged widely from 5 to more than 20 per day. This might be related to employment status.

**Table I - 2. Interview House Characteristics**

<p>What LEED rating did your home obtain? (N= 15)</p>	 <table border="1" data-bbox="902 737 1305 972"> <thead> <tr> <th>Level</th> <th>No. of Respondents</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Platinum</td> <td>0</td> <td rowspan="5">15</td> </tr> <tr> <td>Gold</td> <td>3</td> </tr> <tr> <td>Silver</td> <td>7</td> </tr> <tr> <td>Certified</td> <td>0</td> </tr> <tr> <td>Not sure</td> <td>5</td> </tr> </tbody> </table>	Level	No. of Respondents	Total	Platinum	0	15	Gold	3	Silver	7	Certified	0	Not sure	5
Level	No. of Respondents	Total													
Platinum	0	15													
Gold	3														
Silver	7														
Certified	0														
Not sure	5														
<p>About when was your home built? (N= 15)</p>	 <table border="1" data-bbox="902 1045 1305 1255"> <thead> <tr> <th>Year</th> <th>No. of Respondents</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>2007</td> <td>4</td> <td rowspan="4">15</td> </tr> <tr> <td>2008</td> <td>2</td> </tr> <tr> <td>2009</td> <td>6</td> </tr> <tr> <td>2010</td> <td>3</td> </tr> </tbody> </table>	Year	No. of Respondents	Total	2007	4	15	2008	2	2009	6	2010	3		
Year	No. of Respondents	Total													
2007	4	15													
2008	2														
2009	6														
2010	3														
<p>How long have you lived in your home? (N= 15)</p>															
<p>How many bedrooms do you have in your home? (N= 15)</p>															



## I-2 OVERALL SATISFACTION & QUALITY OF LIFE

This section presents overall satisfaction about the home and neighborhood environments based on the interviews.

### **Satisfaction with home:**

Most interview respondents, 12 out of 15, were highly satisfied with their new homes. Many respondents (6) indicated that their living conditions were significantly improved compared to in their previous housing. Particularly, 6 interview respondents expressed their high excitement about owning homes for the first time and living in new homes:

*“I’m really really happy with this house... We enjoy this house. I really appreciate Habitat for Humanity. It is a blessing to have your own house. I don’t have any stress of renting anymore. It’s my own. My kids and my wife are very happy. It’s a big difference to own my house.” (Case 9)*

*“I love my house, I do, because it’s my own, brand new; I can decorate any kind of way I want. ... I always rented with roommates, never owned; so it’s my first house that I have ever owned in my name. So, it’s awesome.” (Case 3)*

*“To me, it was an opportunity to have in my house what I didn’t have before. To have a house like this is really good. I’m happy with mine.” (Case 15)*

The several features that interviewees specifically mentioned frequently as more satisfactory include “bigger interior spaces,” “more storage spaces,” “having a basement,” “bright interior spaces,” and “having nice outside views.” Three respondents also expressed their satisfaction with improved health conditions, falling sick less often in their current homes because of a cleaner home environment.

### **Satisfaction with neighborhood:**

Nine out of 15 participants expressed their high satisfaction with their neighborhood environments. The major features mentioned by respondents as satisfactory include “good location” (8) such as closeness to schools, bus routes, or grocery stores, “feeling safe” (2), “quiet” (2), and “good neighbors” (4):

*“Neighborhoods are very quiet, and they haven’t had many issues with noise. They are pretty good neighbors. I feel safe.” (Case 8)*

*“Most satisfying feature of the neighborhood environment is that we are close to a bus route and have a] corner store right across the street for food. I have good neighbors.” (Case 3)*

Five interview respondents were less satisfied with their neighborhood conditions. The reasons for dissatisfaction with their neighborhoods include “feeling not safe” (2) because of bad neighborhood conditions such as bars nearby or homeless around and “unsatisfactory neighbors” (4) such as those who made serious noise or troubled the interviewee’s family.

Three out of 5 less-satisfied respondents indicated that they possessed security systems in their homes, which made them feel secure. One respondent stated the following:

*“I’m not satisfied with the neighbor environment... I am not satisfied with neighbors, ... even my next-door neighbor... I don’t want my kids to play with them. They stole from us. So, the biggest reason for dissatisfaction is people and just the environment... There are tattoo shops and bars, and always somebody is moving; lots of homeless people around this area. That’s different. So, I don’t feel safe always... Though my living condition was improved on the point of home space, ... the environment is not improved... I tried to pick the safest place among the houses as a single mother, but this was the best place I could find at that time.” (Case 7)*

Additionally, two interviewees indicated that the playgrounds in their condominiums were not effectively used by kids because they were not appropriate for the ages of any kids in that area:

*“Less satisfied with the playground, which is quite small for children to play in, and we hope to get more facilities such as monkey bars and baby swings.” (Case 4)*

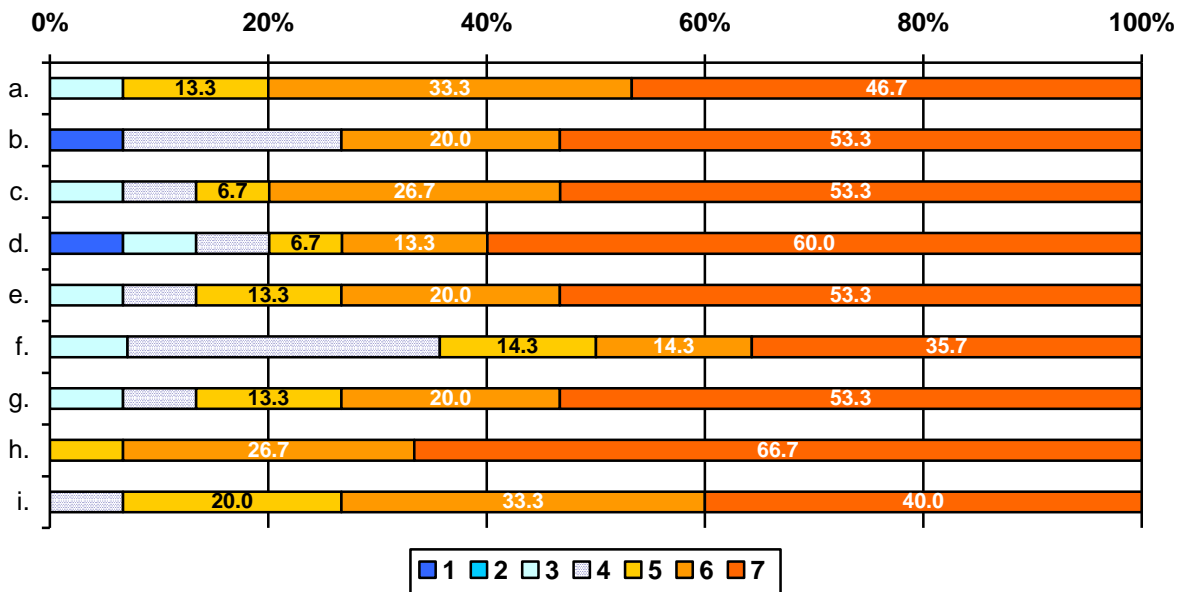
*“Playground area was donated...but the set is too immature for the ages of the children in these homes. Many want to donate the structure because they don’t use it. Instead, a club house for meetings would be more utilized.” (Case 5)*

#### **Overall perceptions about their home environment:**

Interviewees were asked to rate their perceptions of their current homes in terms of comfort, attractiveness, safety, pleasure, convenience, stimuli, sanitation, health, and sustainability. Table I-3 shows that 7 to 10 out of 15 residents indicated the highest value in their perceptions of comfort, attractiveness, safety, pleasure, convenience, sanitation, and health. All residents indicated that their houses are “sustainable” or “very sustainable” and “healthy” or “very healthy.” Yet, fewer residents indicated that their current homes were very stimulating.

**Table I - 3. How residents feel about current home**

	1	2	3	Neutral	5	6	7
	Frequency (%)						
a. 1=Very Uncomfortable 7=Very Comfortable (N=15)	0 (0%)	0 (0%)	1 (6.7%)	0 (0%)	2 (13.3%)	5 (33.3%)	7 (46.7%)
b. 1=Very Unattractive 7=Very Attractive (N=15)	1 (6.7%)	0 (0%)	0 (0%)	3 (20.0%)	0 (0%)	3 (20.0%)	8 (53.3%)
c. 1=Very Unsafe 7=Very Safe (N=15)	0 (0%)	0 (0%)	1 (6.7%)	1 (6.7%)	1 (6.7%)	4 (26.7%)	8 (53.3%)
d. 1=Very Unpleasant 7=Very Pleasant (N=15)	1 (6.7%)	0 (0%)	1 (6.7%)	1 (6.7%)	1 (6.7%)	2 (13.3%)	9 (60.0%)
e. 1=Very Inconvenient 7=Very Convenient (N=15)	0 (0%)	0 (0%)	1 (6.7%)	1 (6.7%)	2 (13.3%)	3 (20.0%)	8 (53.3%)
f. 1=Very not stimulating 7=Very Stimulating (N=14)	0 (0%)	0 (0%)	1 (7.1%)	4 (28.6%)	2 (14.3%)	2 (14.3%)	5 (35.7%)
g. 1=Very Unsanitary 7=Very Sanitary (N=15)	0 (0%)	0 (0%)	1 (6.7%)	1 (6.7%)	2 (13.3%)	3 (20.0%)	8 (53.3%)
h. 1=Very Unhealthy 7=Very Healthy (N=15)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (6.7%)	4 (26.7%)	10 (66.7%)
i. 1=Very Unsustainable 7=Very Sustainable (N=15)	0 (0%)	0 (0%)	0 (0%)	1 (6.7%)	3 (20.0%)	5 (33.3%)	6 (40.0%)



Note (e.g., no.a): 1=Very Uncomfortable, 4=Neutral, 7=Very Comfortable

**Quality of life:**

Many interview respondents indicated that their lives changed since moving into their current homes. Three respondents indicated that their family relationships improved. Other changes in their lives include the comments “socialize more with friends,” “started attending college to get a degree,” and “have more confidence after moving in.”

Many respondents indicated that their child(ren) changed after moving in. Five respondents mentioned that their children are happier and doing better in school, feeling more responsible

because they have their own space. Two respondents indicated that their children have more confidence and less stress, and another respondent mentioned that the children are more interested in extracurricular activities such as learning Spanish or Taekwondo. On the other hand, 3 respondents indicated that their children did not show any difference in their school performance and attitude.

Table I-4 shows how interviewees perceived the changes in their lives since moving into the current homes. The results showed that many of the residents (more than 70% or 80%) agreed or strongly agreed with improved living conditions, improved school performance of their children, improved health of family members, and improved quality of life. Respondents rated a bit low their improved social interaction with neighbors, showing that fewer than half of the residents rated “agree” or “strongly agree.”

**Table I - 4. Changes of living conditions**

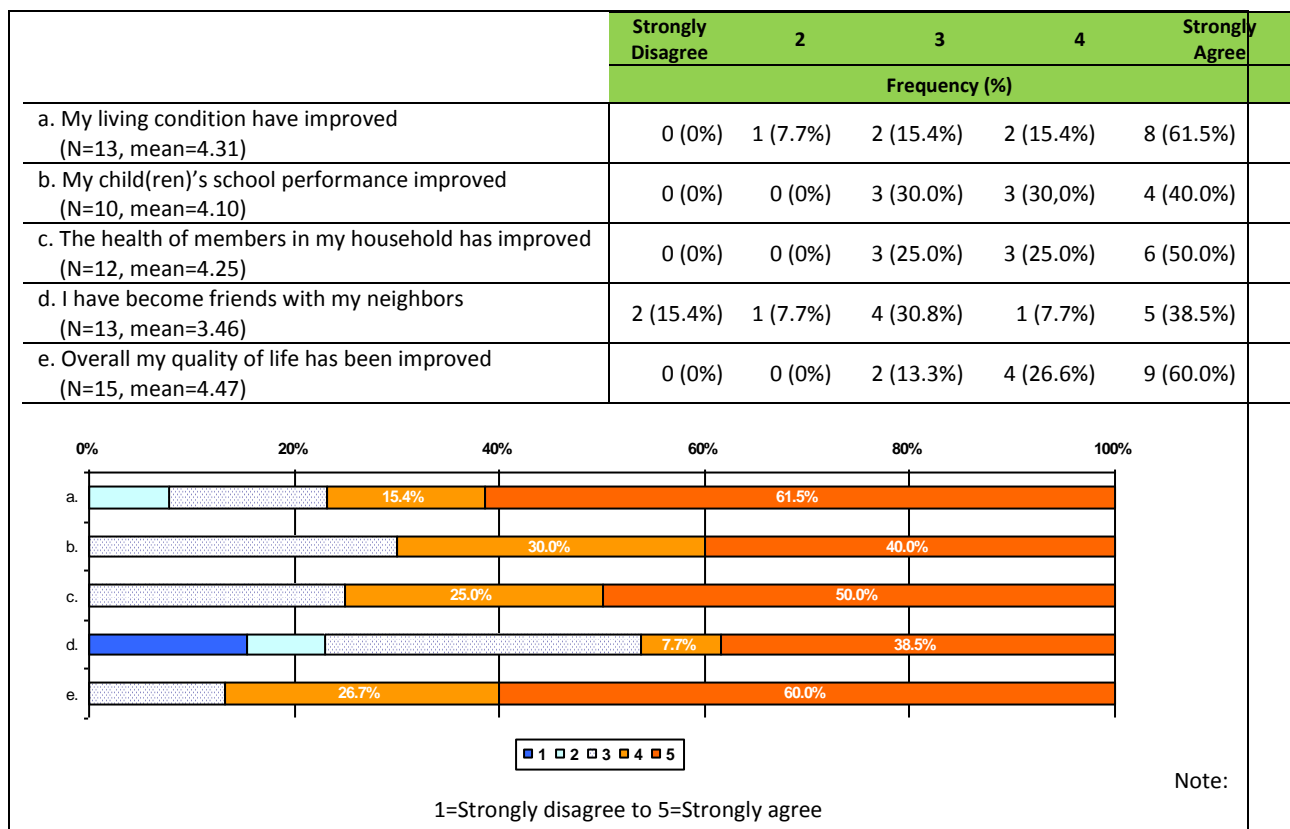
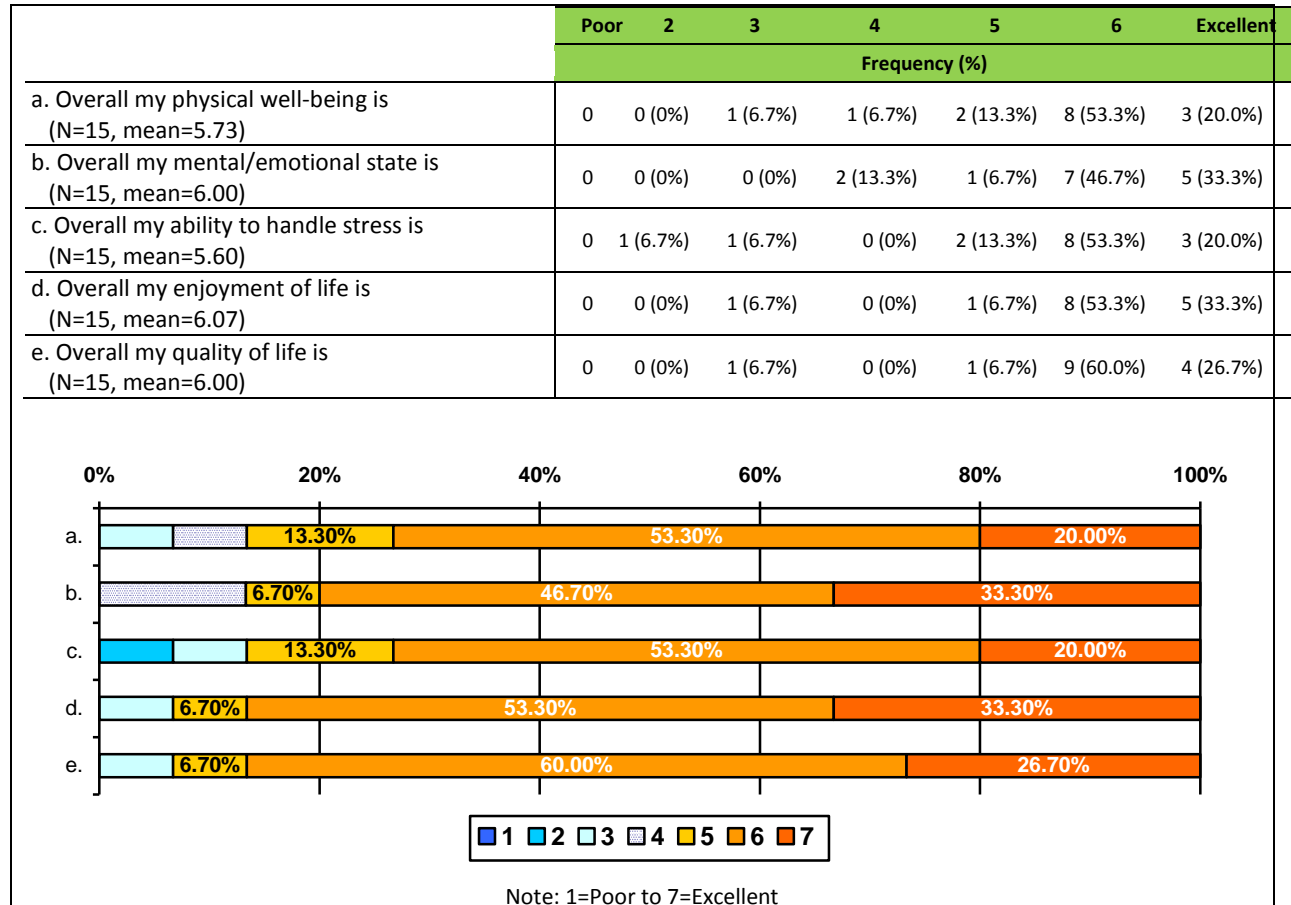


Table I-5 shows interviewees’ ratings about their overall quality of life in their current homes. Specifically, the perceptions of these items were included: overall physical wellbeing, overall mental/emotional state, overall ability to handle stress, overall enjoyment of life, and overall quality of life. Similar to residential satisfaction, perceived quality of life in current homes was reported to be very positive in general. A majority of residents rated their physical wellbeing, mental/emotional state, ability to handle stress, enjoyment of life, and quality of life as “good”

or “excellent.” These results showed that moving to current LEED-certified homes might offer high residential satisfaction and positive perceptions of quality of life.

**Table I - 5. Quality of life in current home**



### I-3 RESIDENT PERCEPTION ABOUT INDOOR ENVIRONMENTAL QUALITY (IEQ)

This section presents the perceptions of residents about the indoor environmental quality of their homes based on the results of the interviews. When asked whether interviewees felt physically and emotionally comfortable in their home environments, most interviewees responded that they felt comfortable with their indoor environmental quality. Few respondents expressed dissatisfaction with some aspects of the indoor environmental quality of their homes. The indoor environmental quality examined in this case study included temperature, humidity, daylight and electrical lighting, air quality and ventilation, and acoustics.

#### **Temperature:**

Indoor temperatures of each case study home in the winter are presented in Table 1-6. The indoor temperatures in the winter ranged from 64°F to 74°F. Most interviewees responded that they feel thermally comfortable with the temperatures of their homes because their heating

systems, insulation, doors, and windows worked efficiently and successfully provided the appropriate thermal conditions in the winter. In the summer, some respondents expressed thermal discomfort amid hot and humid conditions because all Habitat for Humanity homes for this case study didn't possess a central air conditioning system. Ten out of 15 participating homes used room air conditioner(s) for the living room and/or bedrooms, while 5 homes did not use any room air conditioner. Respondents who did not have any room air conditioner indicated that they just used a big fan (2), tried to stay in the basement (2), or opened the window when it was very hot in the summer. Some respondents indicated that certain rooms in their homes such as upstairs bedrooms or any rooms with windows in the west walls were very hot in the summer.

Overall, the respondents expressed high satisfaction about thermal conditions in the winter while showing lower thermal satisfaction in the summer.

**Table I - 6. Case Study Homes' Indoor Temperature Setting in the winter**

Case Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature (°F)	68	70-72	65-73	70-71	68	70-71	72	-	70	-	64-70	-	73	-	65

**Humidity:**

Most interviewees expressed satisfaction with the humidity of their homes. Most of the respondents were pretty happy about the easy control of the humidity levels by using room air conditioners or fans.

**Day & Electrical Lighting:**

Responses about daylight and use of electrical lighting showed definite differences of opinion. Five participants credited enough daylight because of lots of windows. They indicated that they did not turn on any electrical lighting during the daytime. However, 3 interviewees expressed that their homes were dark because of the lack of daylight, and they needed to turn on electrical lighting during the daytime. Also, a couple of respondents were less satisfied with the east-west orientation of their houses because of too-strong afternoon sun in the summer or a lack of sunlight. According to one interviewee,

*“It is dark, and we need more light because other houses are too close and the front of the house is shaded by the overhang.”(Case 8)*

Many interviewees expressed that the quality of their electrical lighting was good and calming to the eyes without any glare. It provides enough light for their interior spaces.

**Air quality & Ventilation:**

Most of the respondents, 8 out of 15, indicated that they have enough cross ventilation due to lots of windows facing each other. There was a stark contrast in respondents’ opinions about



their built-in air exchanger. Nine out of 15 participants agreed that they have nice indoor air quality because the air exchanger performs well:

*“I like the air exchanger because in summer it takes hot air out and brings in cool. In the winter, everything is locked up, so it brings in fresh air without opening windows.” (Case 14)*

*“Silent fans everywhere that can be switched on. I didn’t have to worry about allergies because I have a fresh air system built in; they constantly bring fresh air from outside. ... I love that. All I have to do is... change the air filter.” (Case 3)*

On the other hand, 3 respondents indicated that their air exchangers did not perform well, so they unplugged and did not use them in their homes. The reasons include *“filter blows the smoke in,” “makes the basement freezing in the winter,” “brings cool air with the wind,” “hard to keep the filter clean,” and “it was running my electricity bill.”*

### **Acoustics:**

Most interviewees replied that they felt comfortable with the acoustic conditions and credited the overall acoustic quality as “good.” Interview respondents indicated that they did not experience any serious indoor noise problems except some floors cracking underneath or hearing snoring at night. They are not bothered by any noise from outside when doors and windows are closed, although they can hear big cracks or some traffic from the street once in a while. One interviewee mentioned the following:

*“I have no acoustical issues or problems at all. Walls are pretty thick, and usually noise from outside doesn’t bother me... Between rooms, the walls are pretty thin, and sound can be heard between rooms, but it doesn’t bother me.” (Case 8)*

Table I-7 below shows the level of satisfaction with indoor environmental quality of homes. The features included temperature, humidity, indoor air quality, daylight, artificial light, and acoustic quality.

**Table I - 7. Level of satisfaction with the Indoor Environmental Quality (IEQ)**

	Very Dissatisfied	2	3	4	5	6	Very Satisfied
	Frequency (%)						
a. The temperature in your home (N=15, mean=5.20)	1 (6.7%)	0 (0%)	2 (13.3%)	0 (0%)	4 (26.7%)	5 (33.3%)	3 (20.0%)
b. The humidity in your home (N=13, mean=5.38)	0 (0%)	0 (0%)	2 (15.4%)	1 (7.7%)	3 (23.1%)	4 (30.8%)	3 (23.1%)
c. The air quality in your home (N=15, mean=5.47)	0 (0%)	0 (0%)	2 (13.3%)	1 (6.7%)	4 (26.7%)	4 (26.7%)	4 (26.7%)
d. The amount of daylight in your home (N=15, mean=5.87)	0 (0%)	2 (13.3%)	0 (0%)	0 (0%)	1 (6.7%)	5 (33.3%)	7 (46.7%)
e. The quality and visual comfort of artificial light in your home (N=14, mean=5.71)	0 (0%)	0 (0%)	2 (14.3%)	1 (7.1%)	2 (14.3%)	3 (21.4%)	6 (42.9%)
f. The acoustic quality in your home (N=14, mean=5.29)	0 (0%)	0 (0%)	1 (7.1%)	3 (21.4%)	3 (21.4%)	5 (35.7%)	2 (14.3%)

Note: 1=Very dissatisfied to 7=Very satisfied

Out of 6 indoor environmental qualities, amount of daylight showed the most “very satisfied” (7.0 out of 7.0) ratings, with the highest mean (5.87), followed by quality and visual comfort of artificial lighting (mean=5.71). About 80% (10 to 12) of the respondents rated as “satisfied” or above (5.0 or above out of 7.0) with temperature, humidity, and air quality, while the ratings of air quality showed the highest mean (mean=5.37) among those three.

Acoustic quality was rated relatively low, with the lowest number of “very satisfied” ratings. Ten out of 15 respondents were “satisfied” with the acoustic quality of their homes, but only 2 were “very satisfied” with it. While interview respondents did not mention any serious issues or problems in the acoustic quality of their homes during the interview, overall ratings were relatively low, similarly to many previous POE studies for commercial buildings (see Lee & Kim, 2008).

## I-4 INTERIOR SPACE PLANNING, FURNISHINGS, AND FINISHES

This section presents residents' perceptions of the interior spaces and relevant elements in their homes. Each interviewee addressed different perceptions about space layout, room size, finishes, and furnishings.

### **Space layout:**

Many interviewees specifically mentioned that they liked the space layout of their homes: *"space layout is good to manage," "good connection between rooms," "no unnecessary trip in the indoor space," "like open planning," "good to have children's own room," "enough closet and storage space," "like the separate kitchen,"* and *"have the basement space for children's playing."* Yet, three respondents mentioned that they need more accessible amenities for people with disabilities in their homes (such as a ramp from the garage to inside the home).

### **Room size:**

Five respondents indicated that their room sizes were good, while 2 respondents indicated that they need more space for family gatherings and a larger children's room for accommodating their activities.

### **Finishes & Furnishings:**

Most interviewees like the interior finishes. For example, wood flooring was one of the favored finishes by many respondents because it is less costly for cleaning than carpeted flooring. Some maintenance issues were also mentioned for white walls and shaggy carpet in the heavy-traffic areas. Several homes used a separate vinyl covering or loose carpet swatches over the carpeted floor to keep the carpet clean. (See Figure 1-1)



**Figure 1 - 1. Examples which show clear vinyl covers or loose carpet piece over the carpeted floor**

**Defects in installation, layout, or finishes:**

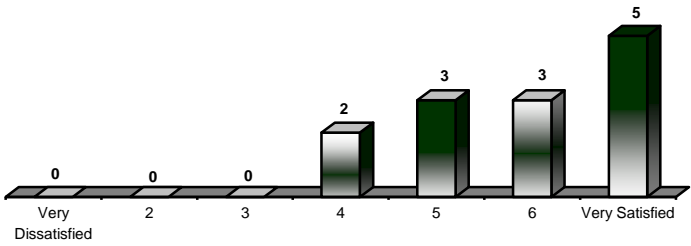
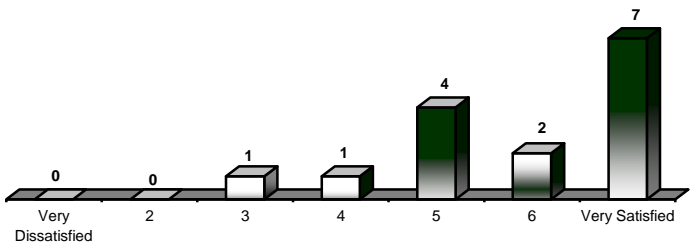
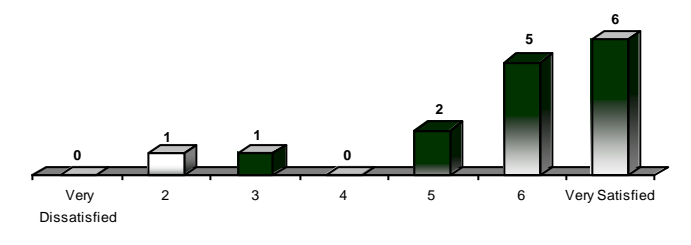
Some defects in installation, layout, or finishes were mentioned by respondents as less-satisfying features. Examples of defects include uneven surfaces of interior finishes, mismatched door knobs, wrong switch/power outlet connections, broken closet doors, and awkward countertop locations. As one of the respondents stated,

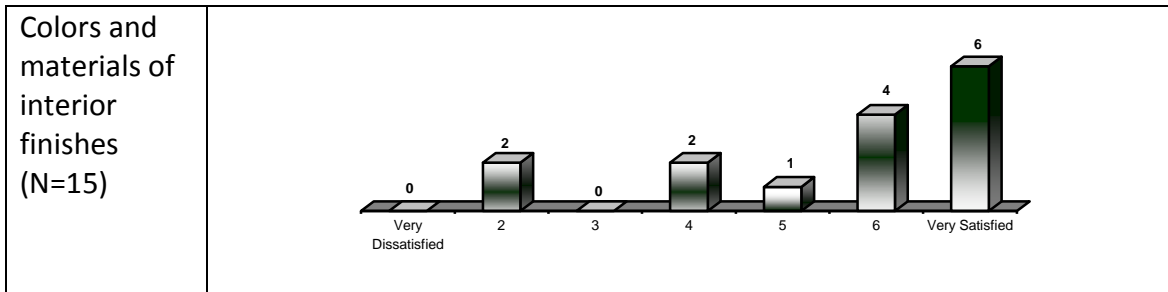
*“Habitat for Humanity homes are constructed too fast, and the volunteers are not professional enough and need more supervision.” (Case 4)*

Table I-8 below shows the levels of satisfaction with Interior design elements: resident satisfaction with space layout, size of space available for daily activities, home furnishings and furniture, and colors and materials of interior finishes.

All respondents were satisfied with the space layouts. All of them rated their space layouts as 4.0 or higher. Their satisfaction with the size of space available for daily activities was also high. Although more than 10 respondents were highly satisfied with “home furnishings and furniture” and the “colors and materials of interior finishes,” some of them were not satisfied with these items at all.

**Table I - 8. Level of satisfaction with the aspects of current home**

<p>Space layout (N=13)</p>	 <table border="1"> <thead> <tr> <th>Rating</th> <th>Number of Respondents</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> </tr> <tr> <td>3</td> <td>0</td> </tr> <tr> <td>4</td> <td>2</td> </tr> <tr> <td>5</td> <td>3</td> </tr> <tr> <td>6</td> <td>3</td> </tr> <tr> <td>Very Satisfied</td> <td>5</td> </tr> </tbody> </table>	Rating	Number of Respondents	0	0	2	0	3	0	4	2	5	3	6	3	Very Satisfied	5
Rating	Number of Respondents																
0	0																
2	0																
3	0																
4	2																
5	3																
6	3																
Very Satisfied	5																
<p>Size of space available for daily activities (N=15)</p>	 <table border="1"> <thead> <tr> <th>Rating</th> <th>Number of Respondents</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>0</td> </tr> <tr> <td>3</td> <td>1</td> </tr> <tr> <td>4</td> <td>1</td> </tr> <tr> <td>5</td> <td>4</td> </tr> <tr> <td>6</td> <td>2</td> </tr> <tr> <td>Very Satisfied</td> <td>7</td> </tr> </tbody> </table>	Rating	Number of Respondents	0	0	2	0	3	1	4	1	5	4	6	2	Very Satisfied	7
Rating	Number of Respondents																
0	0																
2	0																
3	1																
4	1																
5	4																
6	2																
Very Satisfied	7																
<p>Home furnishings and furniture (N=15)</p>	 <table border="1"> <thead> <tr> <th>Rating</th> <th>Number of Respondents</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> </tr> <tr> <td>2</td> <td>1</td> </tr> <tr> <td>3</td> <td>1</td> </tr> <tr> <td>4</td> <td>0</td> </tr> <tr> <td>5</td> <td>2</td> </tr> <tr> <td>6</td> <td>5</td> </tr> <tr> <td>Very Satisfied</td> <td>6</td> </tr> </tbody> </table>	Rating	Number of Respondents	0	0	2	1	3	1	4	0	5	2	6	5	Very Satisfied	6
Rating	Number of Respondents																
0	0																
2	1																
3	1																
4	0																
5	2																
6	5																
Very Satisfied	6																



## I-5 ENERGY EFFICIENCY

This section presents the energy efficiency of green homes based on water, electricity, and natural gas bills reported by interviewees as well as other issues related to energy efficiency of their homes.

### Perception of energy efficiency:

Table I-9 shows the average monthly bills for water, electricity, and natural gas as reported by interviewees. Additionally, interviewees were asked to answer the question ‘Is there [a] big difference in the bills when compared to those of your previous home?’ The answers varied among interviewees.

Eight respondents indicated that they noticed cheaper energy bills in their current homes than in their previous houses. Overall, they saved about 50% maximum on their electricity costs and about 30–50% on their heating bills. One of the respondents mentioned,

*“Electricity went from \$100 in bills to about \$40–50, and with summer it is about \$30.”*  
 (Respondent 4)

Two respondents received bills similar to the previous ones, and 2 respondents received bills higher than those in previous houses. Among those 4 case homes, 1 case was a 1-resident home and 3 cases had 5 or more residents. It is not surprising that a move from a small 1-bedroom apartment to a house would incur higher bills. For big families with 5 or more residents, children were teenagers who took showers many times a day and used computers and video game machines for long hours each day. Energy saving is thus also related to families’ lifestyles and life cycles.

**Table I - 9. Average temperature in home, and average energy bills**

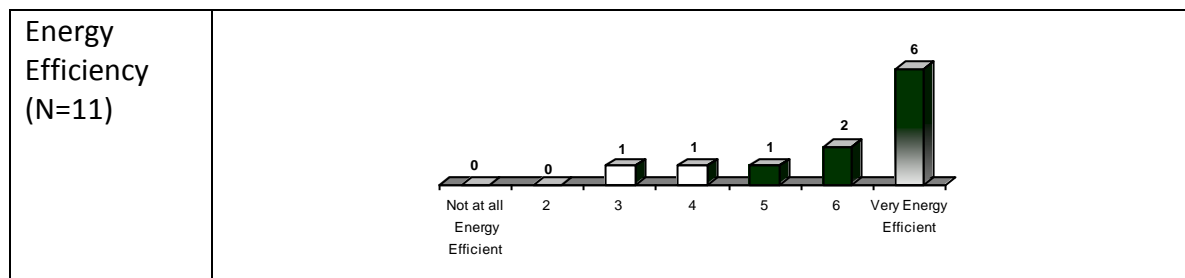
Case	Temperature (F) Summer	Winter	Water bill (\$)		Electricity bill (\$)		Natural gas bill (\$)	
			Summer	Winter	Summer	Winter	Summer	Winter
1		68	Included in the association fee		60	60	9	40
2		70-72	Included in the association fee		50-53	48	32	100
3	75-80	65-73				50-60		
4		70-71			40	40	30	50-60
5		68			30	40-50		
6		70-71	35	35	50-60	50~60	30	40-50
7		72	35	25	150-200	80~100	50	100
8			42	42	60		50	120
9	70	70	40-50	40-50	60	> 60	50	70-80
10	68-70		80-100		80-120	> 80-120		
11	73	64-70	55	55	51	52	23	
12			Included in the association fee					
13	72-75	73	Included in the association fee		100	75	25-30	100
14	70-75		48	48	80-90	80-90		
15		65	42		35			50

**Satisfaction with energy efficiency:**

The main satisfactory features frequently mentioned by respondents included “good insulation with no breeze inside” (4); “effective work of energy-saving equipment and appliances such as windows, furnaces, and water heaters” (7); “lighting system using energy-efficient bulbs” (3); and “water-efficient laundry appliances” (4). Some of the features frequently mentioned by respondents as less satisfactory were mainly related to efficient faucets or toilets. Some of them wanted to replace or already replaced the regular ones that are not efficient.

In addition to answering open-ended questions, interviewees rated the overall efficiency of their homes. Table I-10 below also shows the perceptions of energy efficiency of the current LEED-certified Habitat for Humanity homes. Eight out of 11 respondents who answered this question about overall energy efficiency of their homes rated 6 or 7 points out of 7, indicating “very energy efficient.”

**Table I - 10. Perception about overall energy efficiency of green home performance**



**Building Performance:**

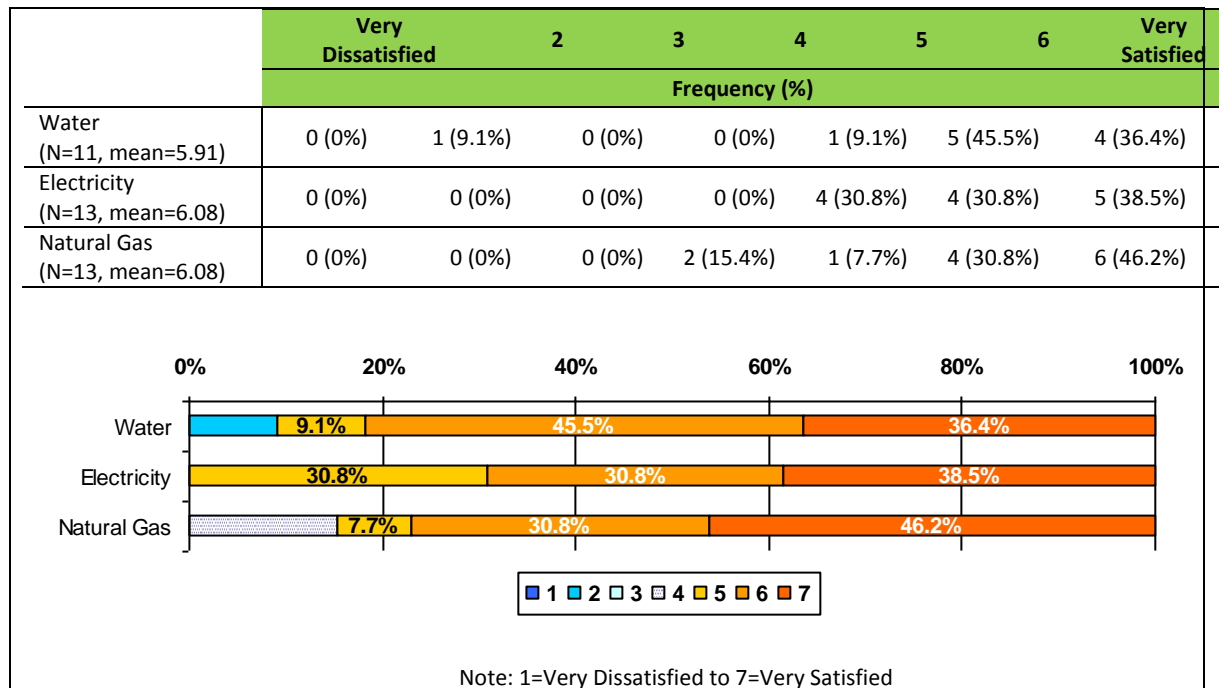
Most interviewees were highly satisfied with the good performance of heating, cooling, and ventilation systems: “centralized heating system is efficient” and the “air exchange system keeps the basement cool in summer without air conditioning and keeps the basement warm in winter.” Several respondents expressed the need for improvements in the HVAC systems in their homes. For example, they wished for a better heating control system, a central air conditioning system, and back screen doors for air circulation.

The majority of the interviewees described lighting fixtures as efficient and switches as working fine, but dimmers or timer switches needed to be added for better efficiency.

Most interviewees responded that the water supply worked well and very efficiently. For example, one respondent appreciated how all toilet units and faucets are water-saving units that function correctly. Yet, some respondents indicated that higher water pressure was needed in bathrooms and the kitchen and that it takes a long time for the water heater to heat water upstairs.

Table I-11 shows interviewees’ ratings for the levels of satisfaction with the energy efficiency of water, electricity, and natural gas (see Table I-11). Overall satisfaction levels for the efficiency of water, electricity, and natural gas were very high. There was no negative response for the efficiency of electricity and natural gas, though a negative response was shown in the efficiency of water.

**Table I - 11. Satisfaction with energy efficiency**



## I-6 PERCEIVED HEALTH IMPACT

This section presents the perceived health impacts of the LEED-certified Habitat for Humanity homes on current residents.

### **Health condition:**

Interviewees were asked whether their family members experienced any changes in their health conditions since moving into the current houses. The family members included the interviewees and other family members living in the current houses.

Three respondents who had family member(s) with asthma indicated that their asthma symptoms were relieved after moving to the current houses, possibly thanks to good ventilation systems. There were 5 respondents with family member(s) with allergies. One of those respondents indicated that the allergies improved, while 2 respondents indicated no change in their allergies. Two respondents indicated adverse effects after moving because their allergies worsened first and then improved after a few weeks. According to an interviewee,

*“I got sick with allergies right after moving into my current home, maybe because of new carpet and the construction dust, but I got better after a few weeks.” (Case 11)*

Other positive responses included improvement with coughs, sore throats, or common colds (3), fewer ear infections (1), reduced smoking (1), less stress (2), and less anxiety (2). About half of the respondents (6) indicated that they were always healthy without any allergies or asthma. Three respondents refused to cite any improvements in their health conditions after moving to the current houses, and several said, “I do not know.” One interviewee indicated that she did not know whether the change was due to moving, as there could be multiple different influences.

## I-7 ENVIRONMENTAL ATTITUDE & BEHAVIOR

This section presents the perceived changes in environmental attitude and environmental behavior after residents moved to the current LEED-certified Habitat for Humanity homes

### **Changes in environmental attitude:**

The interviewees were asked how they perceived any changes in their environmental attitude. Two interviewees clearly stated an increased awareness of environmental issues, increased interest in purchasing green products, and positive changes in their environmental attitudes:

*“I noticed increased interests in purchasing green products and am more aware of the environmental issues, thinking about people 40, 50 years later.” (Case 1)*

*“I am more aware of recycling and trying to keep the home clean.” (Case 4)*

Three respondents indicated that they were a little bit more aware of green products and environmental issues but not entirely:



*“I’m a little bit more green conscious but not entirely.” (Case 3)*

Yet, 5 respondents indicated that they were not interested in environmental issues and found no change in their environmental attitude. One interviewee mentioned,

*“I don’t have time for environmental issues. I don’t have time. I work a lot, 40–60 hours a week...” (Case 10)*

### **Changes in environmental behavior:**

The most noticeable change in environmental behaviors since moving into their current homes was recycling. Eight respondents indicated that they started recycling for the first time ever since moving in. According to those respondents,

*“I started recycling since moving into the current home... Grand Rapids City has a recycling program which gives credits by measuring how much they recycle.” (Case 1)*

*“I started to pay more attention to my footprint, like starting recycling, which I never did before. And I noticed how much trash I don’t have because I do recycle now.” (Case 8)*

*“I have never recycled in my life...now I recycle everything in sight!...not necessarily to be ‘green’ but to save money.” (Case 11)*

Four respondents indicated that they recycled more than before because it is so convenient to recycle in their current homes. One respondent mentioned,

*“I do recycle more now. My parents did recycle at their home, but it wasn’t as easy as it is here, because now they give us a bin... So now I recycle everything recyclable.” (Case 7)*

Respondents indicated that the main reasons why they could recycle more in their homes were having incentives and the ease of the recycling system. Three respondents indicated that they never recycle at all because they do not know what recycling is or how to recycle.

Next, a noticeable change in environmental behavior according to interviewees’ responses was their efforts in saving energy. Seven respondents indicated that they tried to save more energy by turning off lights or electronic appliances while not in use or replacing light bulbs with energy-efficient ones because they wanted to keep their energy bills low. In terms of buying eco-friendly products such as recycled paper towel or eco-friendly detergent, most of them did not care for buying those products; while only 2 respondents indicated that they tried to use eco-friendly products in their everyday lives. Respondents were very sensitive to saving energy but not to buying green products.

*“So now I recycle everything recyclable. I don’t buy a lot of green stuff necessarily.” (Case 7)*

*“And I always also turn off lights. I never really was aware of it before—how much I can save.” (Case 3)*

*“Though I might buy a cheaper brand ... I always buy an energy-efficient brand because it does make a difference.” (Case 7)*

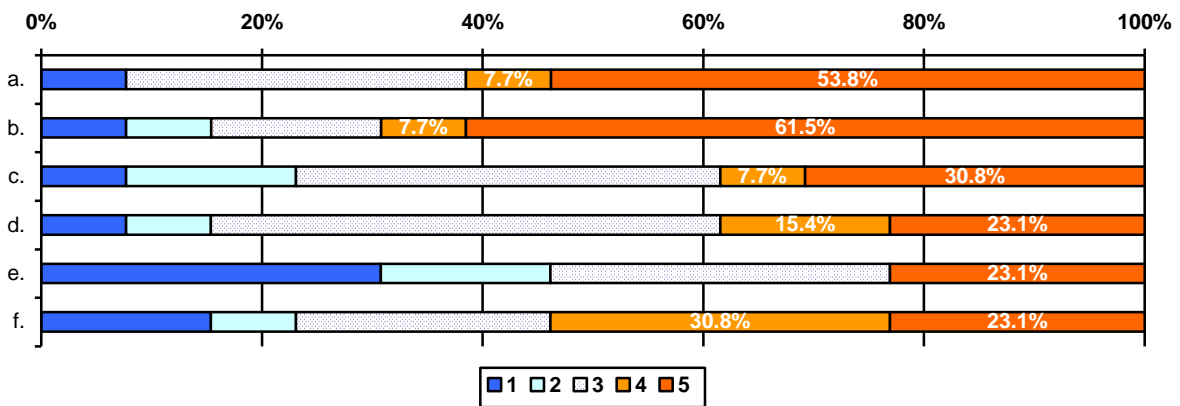
*“I don’t buy eco-friendly products; I just buy the brand I like; but they don’t have some eco-friendly options.” (Case 8)*

Other responses about changes in their environmental behaviors included less use of disposable items such as paper towels (2), carpooling to work (1), and growing tomatoes and peppers (1).

Interviewees were asked to rate how much they were making a special effort to do the following: consider buying Energy Star appliances for the home, consider buying a LEED/green home for their next house, buy products made from recycled materials, buy environment-friendly household chemicals such as cleaning solutions, buy organic fruits and vegetables, and avoid buying products from a company known to be harming the environment. Table I-12 shows the results. As the graphs show, more interviewees were willing to buy Energy Star appliances and LEED-certified or green homes for their next house, while a lot fewer interviewees supported buying products with recycled content and environment-friendly cleaning products. Support was weakest for buying organic fruits and vegetables. They did seem to care about the companies negatively affecting the natural environment.

**Table I - 12. Environmental attitude and behavior**

	To no extent	To some extent	To moderate extent	To a large extent	To a very large extent
	Frequency (%)				
a. Consider buying Energy Star appliances at home (N=13, mean=4.00)	1 (7.7%)	0 (0%)	4 (30.8%)	1 (7.7%)	7 (53.8%)
b. Consider buying LEED/ Green home for your next house (N=13, mean=4.08)	1 (7.7%)	1 (7.7%)	2 (15.4%)	1 (7.7%)	8 (61.5%)
c. Buy products made from recycled materials (N=13, mean=3.38)	1 (7.7%)	2 (15.4%)	5 (38.5%)	1 (7.7%)	4 (30.8%)
d. Buy household chemicals such as cleaning solutions that are environmentally friendly (N=13, mean=3.38)	1 (7.7%)	1 (7.7%)	6 (46.2%)	2 (15.4%)	3 (23.1%)
e. Buy organic fruits and vegetables (N=13, mean=2.69)	4 (30.8%)	2 (15.4%)	4 (30.8%)	0 (0%)	3 (23.1%)
f. Avoid buying products from a company that you know may be harming the environment (N=13, mean=3.38)	2 (15.4%)	1 (7.7%)	3 (23.1%)	4 (30.8%)	3 (23.1%)



Note: 1=To no extent to 5=To a very large extent

### I-8 INFORMED ABOUT LEED

LEED-certified homes require an additional process in the general house delivery process: the certification application process. LEED-certified home development also requires the homeowner education and awareness process (USGBC, 2009). The interview thus asked whether residents were fully informed about this LEED certification process. Levels of understanding and acceptance about the associated higher initial cost with these certifications were investigated.

Only 3 interviewees indicated that they were well informed, and 4 interviewees indicated that they did not know that their homes were LEED certified until moving in or until now. Three respondents indicated that they were informed about LEED but they had no idea about the influence of a LEED-certified home process. Five respondents indicated that they did not clearly

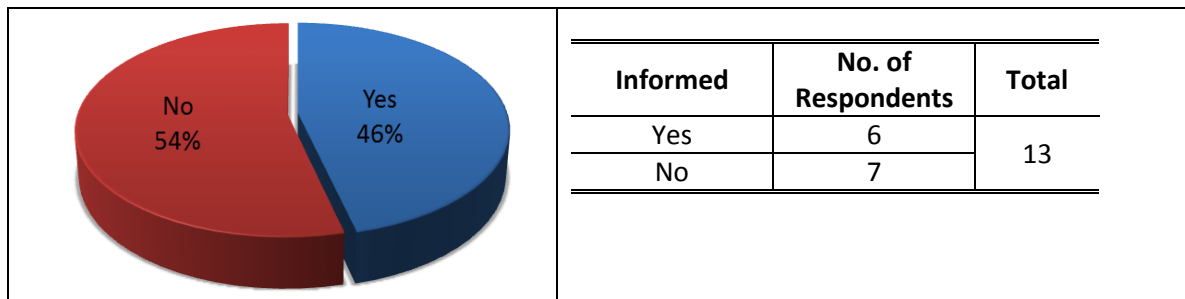
understand LEED because of the lack of detailed information provided for them or the lack of residents' interest in attending any educational seminars about LEED-certified homes.

*"I took lots of classes, but I don't really remember about LEED. Just excited at the fact that I got my first own house and was moving. I was not informed that I need to pay little bit more for the LEED-certified home." (Case 8)*

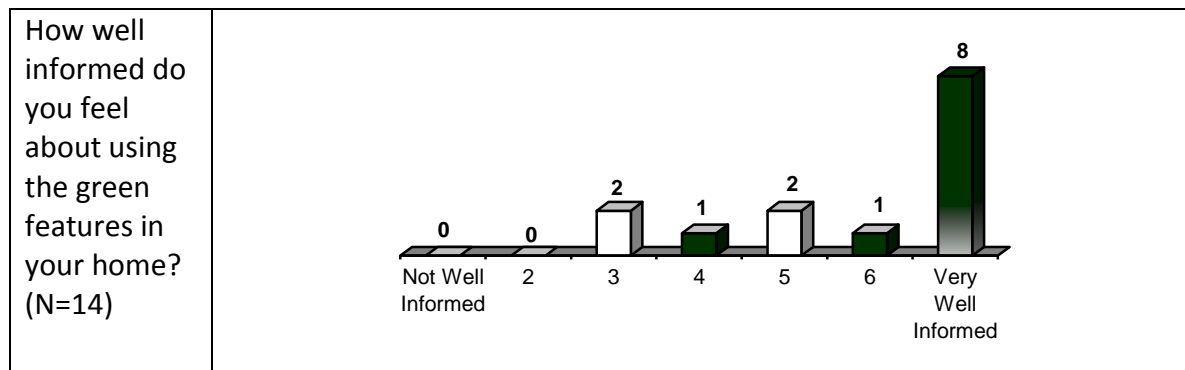
One remembered hearing about the higher initial cost, but most respondents said that they did not know about these costs.

Tables I-13 and I-14 shows how many interviewees indicated that they were informed about LEED and how well they perceived themselves to be informed. More than half of the interviewees were not informed enough about their LEED-certified homes. A majority of interviewees, however, agreed that they were well informed about how to use energy-efficient features of their green homes.

**Table I - 13. Informed about LEED/ green building?**



**Table I - 14. Informed how to use energy efficient features of green home?**



**Perception about LEED-certified homes:**

Finally, interviewees were asked about their general opinions about LEED-certified homes, whether they would recommend this green home to other people, and whether they would prefer moving into a LEED-certified home when they need to move in the future. About half of the respondents stated that it was worth paying the higher initial cost for a LEED-certified home,

as they were rewarded by lower utility bills. Most interviewees indicated that they would prefer moving to a LEED-certified home in the future. A few were not sure. Respondents also recommended that contractors should have better communication with homeowners to ensure continuing education for proper maintenance and residency in LEED-certified homes.

## PART II RESULTS FROM SURVEY

This part presents the results of the quantitative research utilizing mailed-in surveys. Two hundred and thirty-five people living in LEED-certified homes in Michigan, Minnesota, Missouri, Ohio, Illinois, and Indiana (US) responded to this study. The results included:

- II-1. Survey participants
- II-2. Satisfaction with home environment
- II-3. Family's well-being
- II-4. Energy efficiency
- II-5. Environmental attitude & behavior

### II-1 SURVEY PARTICIPANTS

In collaboration with the Alliance for Environmental Sustainability (AES), 605 mail surveys were distributed. 235 were returned and all of these were usable. The response rate was 38.8%. This section presents survey participants' characteristics, and the characteristics of their homes.

Table II-1 shows the socio-demographic information of survey participants. The sample included respondents of several age groups. Approximately 10% were in their 20s or younger; 35% were in their 30s and 40s; and 55% of residents were in their 50s or older. About 42.5% were male and 57.5% were female. Most of the respondents were white (68.6%), and the remaining respondents were Black/African-American (19.5%), American Indian/Alaska Native (2.5%), Asian (2.1%), Native Hawaiian/other Pacific Islander (0.8%), and others.

In terms of marital status, approximately 36% of the respondents were married, 26.5% were single who had never married, 20.4% were divorced. As far as the employment status is concerned, nearly half of the respondents (42.8%) were full or part-time employees. Among the respondents, 21.4% were retired, 11.8% were unable to work, 7.9% were unemployed, 6.1% were self-employed and 10% had their status as other, such as stay at home moms or students.

**Table II - 1. Survey Participants' Demographics**

<b>Demographics</b>	<b>Frequency</b>	<b>Percent</b>
<b>Age (N=232)</b>		
29 years or younger	24	10.3
30-39	45	19.4
40-49	34	14.7
50-59	56	24.1
60-69	43	18.5
70 years or older	30	12.9
<b>Gender (N=233)</b>		
Male	99	42.5
Female	134	57.5
<b>Race (N*=236) * Respondents may check multiple answers</b>		
White	162	68.6
Black or African-American	46	19.5
Native Hawaiian or other Pacific Islander	2	0.8
Asian	5	2.1
American Indian or Alaska Native	6	2.5
Other (Hispanic (n=3), Mexican, Multi-racial (n=2), Philippines, Spanish, Spanish-French)	15	6.4
<b>Marital Status (N=230)</b>		
Married	83	36.1
Never married	61	26.5
Divorced	47	20.4
Member of an unmarried couple	8	3.5
Widowed	29	12.6
Separated	2	0.9
<b>Employment Status (N=229)</b>		
Employed full or part-time	98	42.8
A homemaker	7	3.1
Unable to work	27	11.8
Self-employed	14	6.1
A student	4	1.7
Unemployed	18	7.9
Retired	49	21.4
Other (Disabled (n=3) / SSD / SSI / Stay at home mom)	12	5.2

Table II-1 below shows the respondents' education, income, and state of residents. Nearly all (91.5%) had at least a high school diploma. About half (48.3%) had completed at least one year of college, and 21.4% had graduate or professional degrees. This shows that they were educated enough to understand the contents of the survey. Approximately 43% of the respondents identified their annual gross household income as less than \$20,000. About 35% of the respondents' income ranged from \$20,000 to \$99,999. About 22% of the respondents reported an income on \$100,000 or more. More than half of the respondents resided in Michigan (55.7%). The others were from Ohio (25.7%), Indiana (9.1%), Minnesota (4.3%), Wisconsin (2.6%), Illinois (1.7%), and Wisconsin (2.6%).

**Table II - 1. Survey Participants' Demographics (Continued)**

<b>Demographics</b>	<b>Frequency</b>	<b>Percent</b>
<b>Education Level (N=234)</b>		
Completed grade school	1	0.4
Some high school	19	8.1
Completed high school or GED	51	21.8
Some college or technical school	62	26.5
4-year college degree	51	21.8
Graduate or professional degree	50	21.4
<b>Household Income (N=219)</b>		
Less than \$20,000	93	42.5
\$20,000 to \$39,999	43	19.6
\$40,000 to \$59,999	16	7.3
\$60,000 to \$79,999	9	4.1
\$80,000 to \$99,999	10	4.6
\$100,000 and over	48	21.9
<b>Residential Region (N=230)</b>		
Illinois	4	1.7
Indiana	21	9.1
Michigan	128	55.7
Minnesota	10	4.3
Missouri	2	0.9
Ohio	59	25.7
Wisconsin	6	2.6



Table II-2 depicts survey respondents' housing characteristics. Nearly half (43%) of the respondents lived in apartments, 28.3% were in single-family detached houses, 15.3% were in multi-family houses such as condominiums or townhomes. About 46.8% of the respondents owned their homes and 46.8% were renters.

Nearly 40% of the homeowners did not remember their LEED certification level. About 15.8% were platinum-certified, 14% were gold-certified, 21.9% were silver-certified, and 9.8 were certified. About 4.4% had been built before 2000, 15.6% between 2002 and 2006, and 80.1% between 2007 and 2011. About 87.2% have lived in their current home for less than five years.

Table II-2 also shows square footage and the number of stories of the LEED-certified homes, number of bedrooms, and number of resident adults and children. Only 142 respondents indicated their square footage. About 26.7% of 142 homes were less than 1,000 square feet, about 42.3% were between 1,000 and 2,000 square feet, about 25.9% were between 2,000 and 5,000 square feet, and about 4.9% were more than 5,000 square feet. About 30% of respondents had one bedroom, 26.6% had two, 25.3% had three, and 18% had between four and six.

Survey respondents were asked if their homes had been built by Habitat for Humanity. About 16% of homes were built by Habitat for Humanity. About 7.2% of respondents spent less than 10 hours a day at home, 38.1% spent about 10 to 14, 26.9% spent 15 to 19, and 27.8% spent more than 20 hours at home, including sleeping. Half of the households had one adult (52.2%), 39.9% had 2 and 8.8% had 3 to 6. About 70.5% of households had no child, 10.7% had one, and 18.7% had between two and seven.

**Table II - 2. Survey Houses' Characteristics**

<b>Green Home Characteristics</b>		<b>Frequency</b>	<b>Percent</b>
<b>Type of Home</b> (N=235)	Single-family detached house	90	38.3
	Apartment Building	101	43.0
	Condominium, duplex, or townhome (multi-family attached)	36	15.3
	Other	8	3.4
<b>Own or rent home</b> (N=235)	Own Home	110	46.8
	Rent Home	110	46.8
	Other	15	6.4
<b>LEED rates</b> (N=215)	Platinum	34	15.8
	Gold	30	14.0
	Silver	47	21.9
	Certified	21	9.8
	Not Sure	83	38.6
<b>Year of home built</b> (N=205)	2002 and before	10	4.9
	2003	2	1.0
	2005	6	2.9
	2006	23	11.2
	2007	27	13.2
	2008	28	13.7
	2009	58	28.3
	2010	42	20.5
<b>How long have you lived</b> (N=210)	2011	9	4.4
	Less than 1 year	23	11.0
	1 year to 1 year and 11 months	58	27.6
	2 years to 2 years and 11 months	60	28.6
	3 years to 3 years and 11 months	27	12.9
	4 years to 4 years and 11 months	15	7.1
	5 years to 5 years and 11 months	21	10.0
6 years and more	6	2.9	

**Table II - 2. Survey Houses' Characteristics (Continued)**

<b>Green Home Characteristics</b>		<b>Frequency</b>	<b>Percent</b>
<b>Square footage of your home (N=142)</b>	Less than 500 sqft	4	2.8
	500 to 999	34	23.9
	1,000 to 1,499	36	25.4
	1,500 to 1,999	24	16.9
	2,000 to 2,499	7	4.9
	2,500 to 2,999	8	5.6
	3,000 to 3,499	9	6.3
	3,500 to 3,999	3	2.1
	4,000 to 4,999	10	7.0
	5,000 and more	7	4.9
<b>No. of bedrooms (N=229)</b>	1 bedroom	69	30.1
	2 bedrooms	61	26.6
	3 bedrooms	58	25.3
	4 bedrooms	21	9.2
	5 bedrooms	13	5.7
	6 bedrooms	7	3.1
<b>Built by Habitat for Humanity (N=208)</b>	Yes	33	15.9
	No	175	84.1
<b>Hours spending at home (including sleeping) (N=223)</b>	Less than 10 hours	16	7.2
	10 to 14 hours	85	38.1
	15 to 19 hours	60	26.9
	More than 20 hours	62	27.8
<b>No. of adults (18 years of age or older) (N=228)</b>	1 adult	119	52.2
	2 adults	89	39.0
	3 adults	12	5.3
	4 and more adults	8	3.5
<b>No. of children (under the age of 18) (N=224)</b>	0 child	158	70.5
	1 child	24	10.7
	2 children	22	9.8
	3 children	12	5.4
	4 and more children	8	3.5

## II-2 SATISFACTION WITH HOME ENVIRONMENT

Occupants' satisfaction with the home environment was investigated with seven categories:

- Overall satisfaction
- Satisfaction with various aspects of home environment
- Perceived importance of various aspects of home environment
- Perceived quality of life in LEED-certified home
- Perceived improvement of quality of life
- Indoor environmental quality
- Housing perception

### **Overall Satisfaction:**

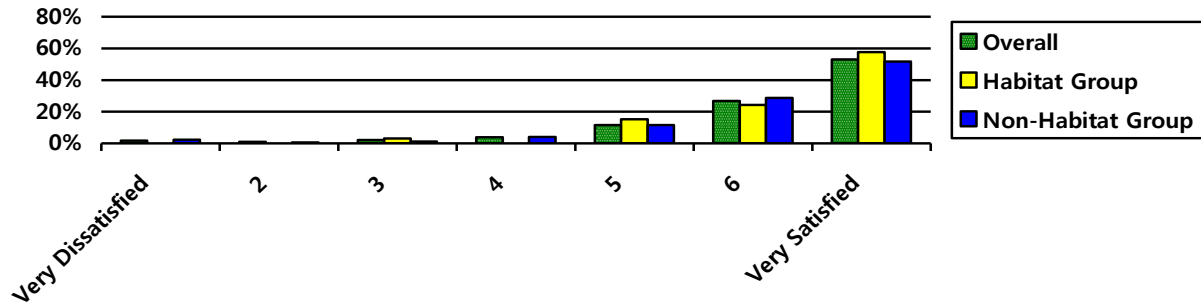
Respondents were asked "In general, how satisfied or dissatisfied are you with your current LEED certified home?" The answers were ranked 1 (very dissatisfied) to 7 (very satisfied). About 91.3% of the respondents indicated that they were satisfied or very satisfied, and 4.8% responded that they were dissatisfied or very dissatisfied (see Table II-3).

Respondents were also asked "In general, how satisfied or dissatisfied are you with your current neighborhood?" About 85.2% indicated that they were satisfied or very satisfied, and 6.9% responded that they were dissatisfied or very dissatisfied (also see Table II-3).

The mean scores of overall satisfaction were compared between the respondents whose houses were built by Habitat for Humanity ("Habitat group") and the respondents whose houses were not built by Habitat for Humanity ("Non-Habitat group")(See table II-3). The mean value of satisfaction with a current LEED certified home for the Habitat group (mean=6.33) was higher than the mean value for the Non-Habitat group (mean=6.15). In contrast, the mean value of satisfaction with their neighborhood for the Habitat group(mean=6.45) was lower than the mean value for the Non-Habitat group (mean=6.95). Although the mean differences between the two groups were not statistically significant, these results illustrated the potential differences in satisfaction levels between the two groups. Households of the Habitat group tend to be more satisfied with their LEED-certified home, possibly because of owning their own homes/rooms for the first time as shown in the case studies. Households of the Habitat group tend to be less satisfied with their neighborhood, probably because of difficulties to become friends with their neighbors or safety issue for some families as case studies indicated.

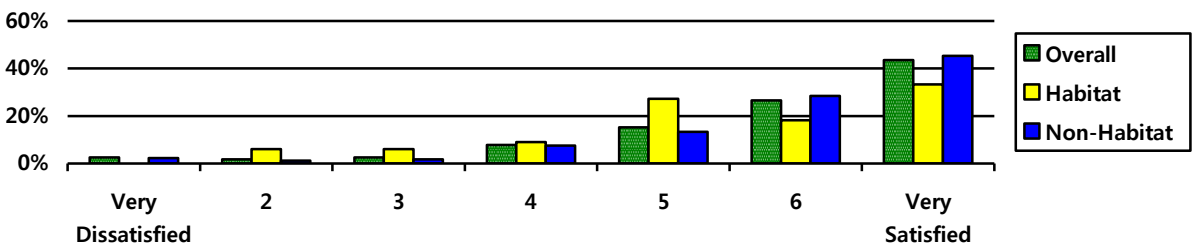
**Table II - 3. Overall satisfaction**

In general, how satisfied or dissatisfied are you with your current LEED certified home?										
	Very Dissatisfied	2	3	4	5	6	Very Satisfied	N	Mean	Standard Deviation
	Frequency (%)									
Overall	4 (1.7%)	2 (0.9%)	5 (2.2%)	9 (3.9%)	27 (11.6%)	62 (26.7%)	123 (53.0%)	232	6.15	1.24
Habitat Group	0 (0%)	0 (0%)	1 (3.0%)	0 (0%)	5 (15.2%)	8 (24.2%)	19 (57.6%)	33	6.33	0.96
Non-Habitat Group	4 (2.3%)	1 (0.6%)	2 (1.1%)	7 (4.0%)	20 (11.5%)	50 (28.7%)	90 (51.7%)	174	6.15	1.25



**In general, how satisfied or dissatisfied are you with your current neighborhood?**

In general, how satisfied or dissatisfied are you with your current neighborhood?										
	Very Dissatisfied	2	3	4	5	6	Very Satisfied	N	Mean	Standard Deviation
	Frequency (%)									
Overall	6 (2.6%)	4 (1.7%)	6 (2.6%)	18 (7.8%)	35 (15.2%)	61 (26.5%)	100 (43.5%)	230	5.85	1.43
Habitat	0 (0%)	2 (6.1%)	2 (6.1%)	3 (9.1%)	9 (27.3%)	6 (18.2%)	11 (33.3%)	33	5.45	1.50
Non-Habitat	4 (2.3%)	2 (1.2%)	3 (1.7%)	13 (7.6%)	23 (13.4%)	48 (28.5%)	78 (45.3%)	172	5.95	1.35

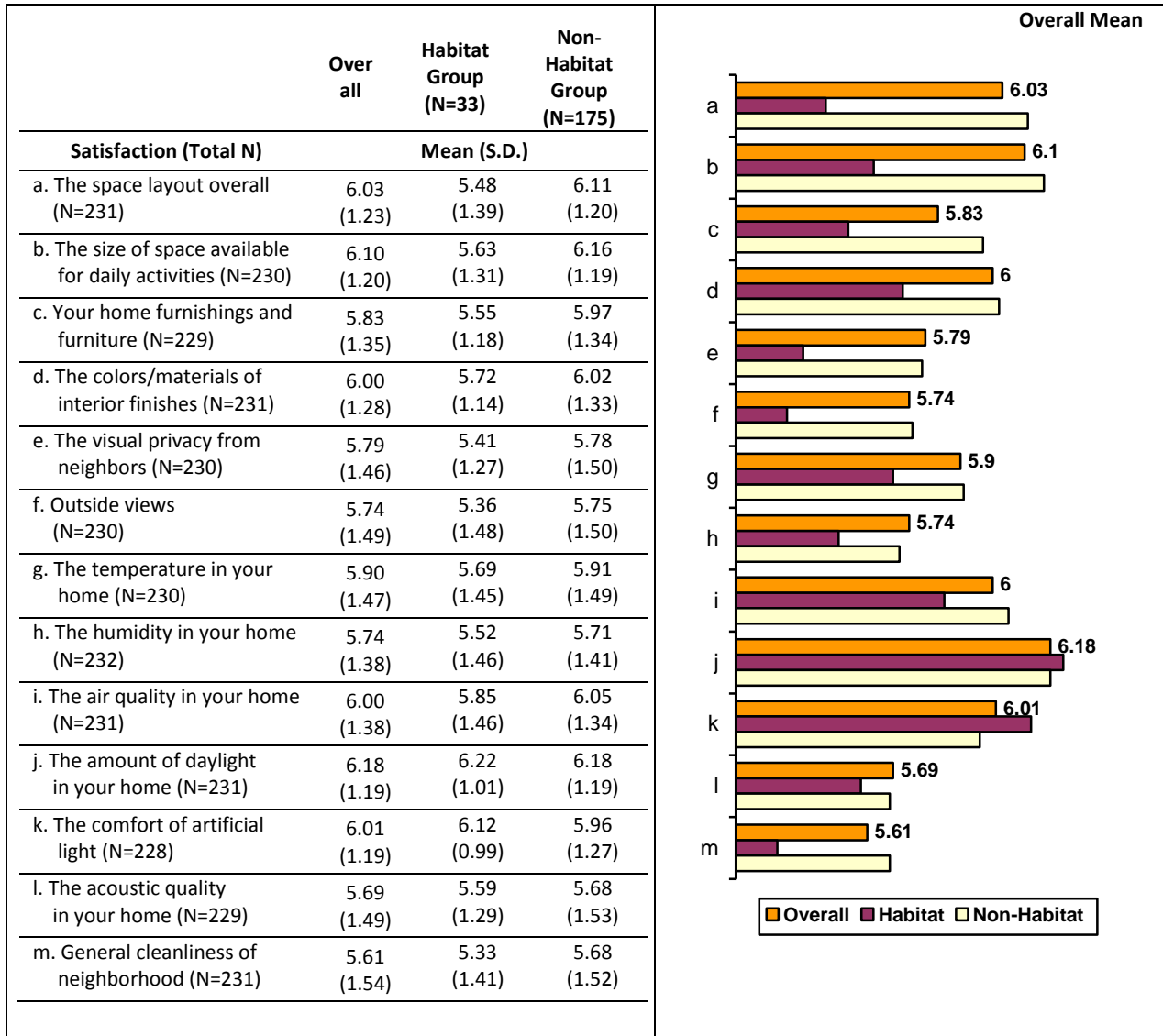


### **Satisfaction with various aspects of home environment:**

Survey participants were asked to rate their satisfaction with 13 aspects of the home environment (Table II-4). The average ratings of all 13 aspects of home environment were "satisfied" or above (5.0 or above out of 7.0). The highest-rated aspect was "the amount of daylight" (mean=6.18), followed by "the amount of space available for daily activities" (mean=6.10), "the space layout overall" (mean=6.03), "the comfort of artificial light" (mean=6.01). The lowest-rated aspect was "general cleanliness of neighborhood environment" (mean=5.61), followed by "the acoustic quality" (mean=5.69), "outside views" (mean=5.74), and "the humidity" (mean=5.74).

Table II-4 also compares the mean scores between the Habitat and Non-Habitat groups. The Habitat group showed slightly greater satisfaction level than Non-Habitat group only for "the amount of daylight" and "the comfort of artificial light" while showed lower satisfaction level than Non-Habitat group for all other aspects of home environment. Although the mean differences between the two groups were not statistically significant, these results illustrate that the overall satisfaction of Habitat group with their current home was higher than that of the Non-Habitat group (see Table II-3), but their satisfaction with specific aspects of home environments was generally lower than that of the Non-Habitat group (see Table II-4).

**Table II - 4. Level of satisfaction with various home aspects**



**Perceived importance of various aspects of home environment:**

Survey participants were asked to rate the perceived importance of 13 aspects of their home environment for their overall residential comfort and satisfaction. Mean values of the perceived importance of these aspects were calculated. Table II-5 presents the most important aspect among the 13 was “air quality” (mean=6.31), followed by “amount of daylight” (mean=6.21), “temperature” (mean=6.19), “space layout overall” (mean=6.14). The lowest-rated aspect was “home furnishings and furniture” (mean=5.64), followed by “the colors/materials of interior finishes” (mean=5.70), “acoustic quality” (mean=5.70), and “comfort of artificial light” (mean=5.94).

Table II-5 shows mean score comparisons between the Habitat group and Non-Habitat group. The Habitat group showed lower perceived importance levels for most of home aspects than the Non-Habitat group but slightly higher perceived importance levels in “humidity,” “air quality,” and “acoustic quality,” and “general cleanliness of neighborhood” than the Non-Habitat group. Their perceived importance level with “amount of space for daily activities” was the same as that of the Non-Habitat group.

**Table II - 5. Level of importance of home aspects**

	Over all	Habitat Group (N=33)	Non-Habitat Group (N=175)
Perceived Importance	Mean (S.D.)		
a. The space layout overall (N=230)	6.14 (1.23)	6.06 (1.25)	6.17 (1.20)
b. The size of space for daily activities (N=229)	6.13 (1.21)	6.12 (1.27)	6.12 (1.22)
c. Your home furnishings and furniture (N=230)	5.64 (1.35)	5.61 (1.30)	5.69 (1.35)
d. The colors/materials of interior finishes (N=228)	5.70 (1.32)	5.61 (1.34)	5.72 (1.32)
e. The visual privacy from neighbors (N=230)	5.95 (1.32)	5.70 (1.38)	5.94 (1.34)
f. Outside views (N=231)	5.96 (1.27)	5.76 (1.32)	5.98 (1.31)
g. The temperature in your home (N=231)	6.19 (1.18)	6.00 (1.46)	6.21 (1.11)
h. The humidity in your home (N=230)	5.98 (1.28)	5.97 (1.49)	5.91 (1.29)
i. The air quality in your home (N=229)	6.31 (1.15)	6.30 (1.21)	6.28 (1.18)
j. The amount of daylight in your home (N=229)	6.21 (1.09)	6.09 (1.21)	6.23 (1.07)
k. The comfort of artificial light (N=227)	5.94 (1.21)	5.82 (1.24)	5.92 (1.24)
l. The acoustic quality in your home (N=223)	5.70 (1.39)	5.74 (1.32)	5.67 (1.40)
m. General cleanliness of neighborhood (N=227)	5.95 (1.38)	5.97 (1.40)	5.95 (1.35)

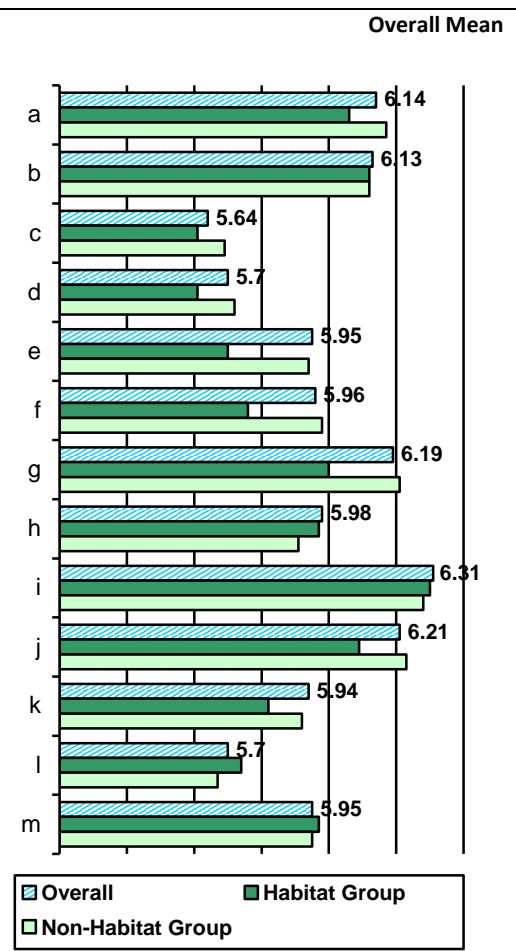
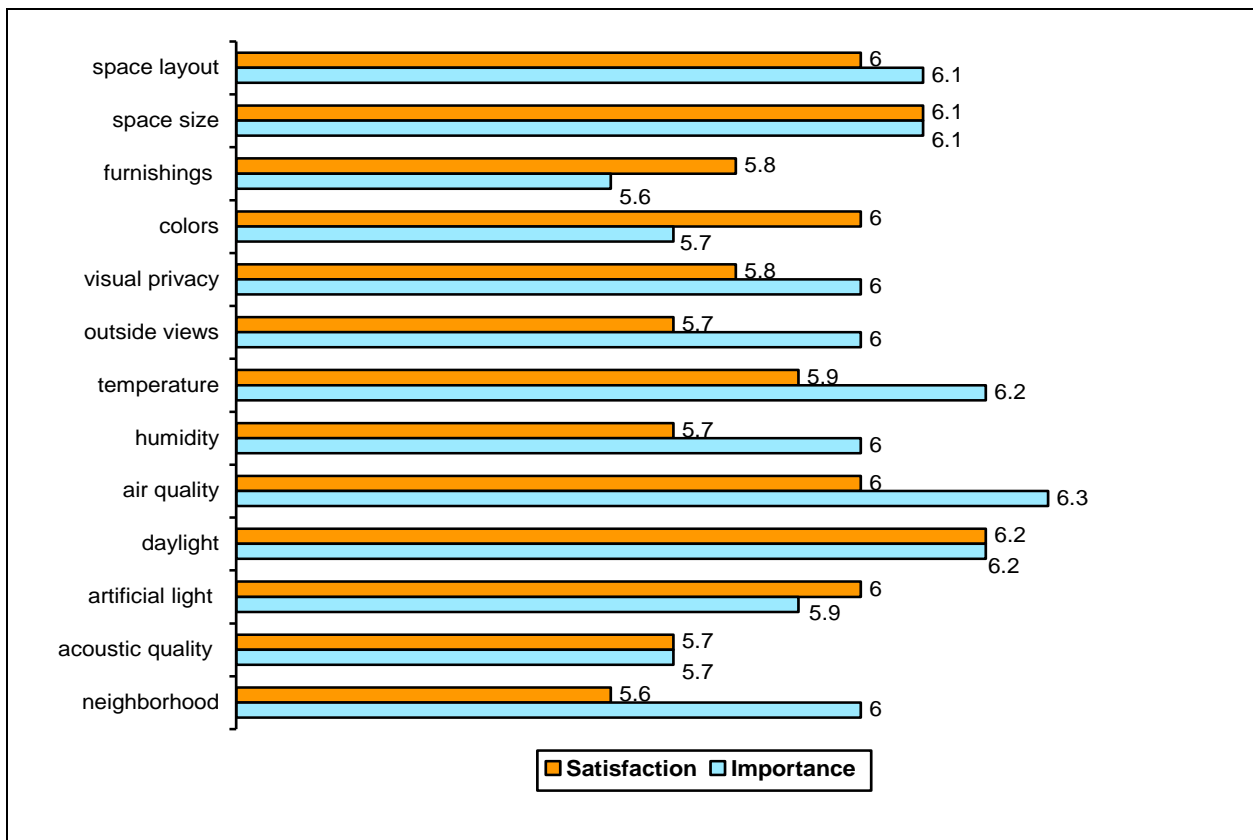




Table II-6 shows the mean differences between their satisfaction and perceived importance for 13 aspects. The levels of satisfaction were lower than their perceived levels of importance in most aspects, except “home furnishings and furniture,” “colors/materials of interior finishes,” and “comfort of artificial light.” The biggest mean difference between satisfaction and importance was “general cleanliness of neighborhood” (mean difference (md) = satisfaction mean – importance mean, md=-0.34), followed by “air quality” (md=-0.31), and “temperature” (md=-0.29).

**Table II - 6. Comparing means of satisfaction and importance**



\* Mean was computed based on 7 point Likert scale, 1=Very dissatisfied to 7=Very satisfied.

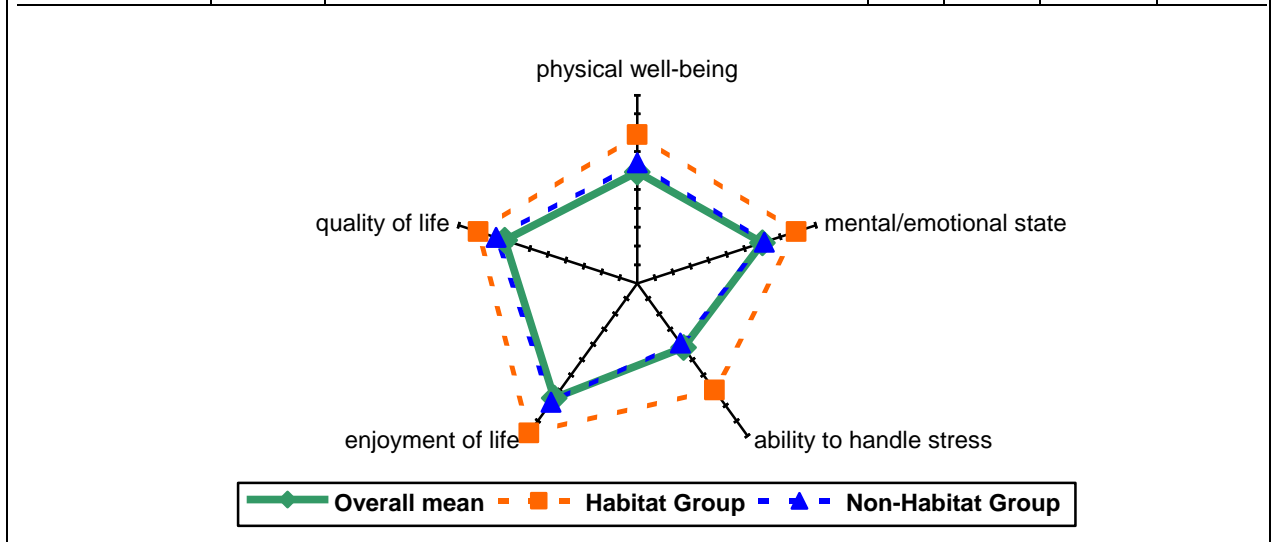
**Perceived quality of life:**

Table II-7 shows the mean values of the perceived quality of life in LEED-certified homes. Mean values were calculated for each aspect of quality of life on a scale of 1 to 7, where 1 is "very poor" and 7 is "excellent." Respondents perceived "mental/emotional state" (mean=6.0), "enjoyment of life" (mean=6.0), and "quality of life" (mean=6.0) as excellent. The lowest value of quality of life was "ability to handle stress" (mean=5.7).

The mean value for each aspect of quality of life was compared between the Habitat and Non-Habitat groups (See table II-7). Mean values for all the five aspects of quality of life were higher in the Habitat group than in the Non-Habitat group. This results could be associated with the higher residential satisfaction of Habitat group with their current LEED-certified homes. Residents of Habitat for Humanity households tended to perceive their physical and emotional well-being, ability to handle stress and enjoyment of life, and overall quality of life in a more positive manner than did the Non-Habitat group. This result shares the similar understanding reached about Habitat for Humanity homes and households. Although the mean values between Habitat and non-Habitat groups were slightly different, the respondents in both groups ranked highest the "enjoyment of life," and ranked lowest the "ability to handle stress."

**Table II - 7. Quality of life in LEED certified homes**

		Overall								Total N	Mean (S.D.)	Habitat Group (N=33)	Non-Habitat (N=175)
		Poor	2	3	4	5	6	Excellent	Mean(S.D.)			Mean(S.D.)	
physical well-being	Frequency	2	4	11	14	32	73	93	229	5.89 (1.31)	6.09 (1.06)	5.94 (1.26)	
	Percent	0.9%	1.7%	4.8%	6.1%	14.0%	31.9%	40.6%					
mental/emotional state	Frequency	2	3	6	17	34	60	108	230	6.00 (1.28)	6.19 (1.03)	6.01 (1.28)	
	Percent	0.9%	1.3%	2.6%	7.4%	14.8%	26.1%	47.0%					
ability to handle stress	Frequency	2	4	8	24	36	86	69	229	5.72 (1.27)	6.00 (0.76)	5.69 (1.37)	
	Percent	0.9%	1.7%	3.5%	10.5%	15.7%	37.6%	30.1%					
enjoyment of life	Frequency	2	3	2	14	35	71	102	229	6.05 (1.16)	6.28 (0.81)	6.08 (1.21)	
	Percent	0.9%	1.3%	0.9%	6.1%	15.3%	31.0%	44.5%					
quality of life	Frequency	2	1	3	18	33	72	101	230	6.04 (1.14)	6.19 (0.69)	6.09 (1.18)	
	Percent	0.9%	0.4%	1.3%	7.8%	14.3%	31.3%	43.9%					



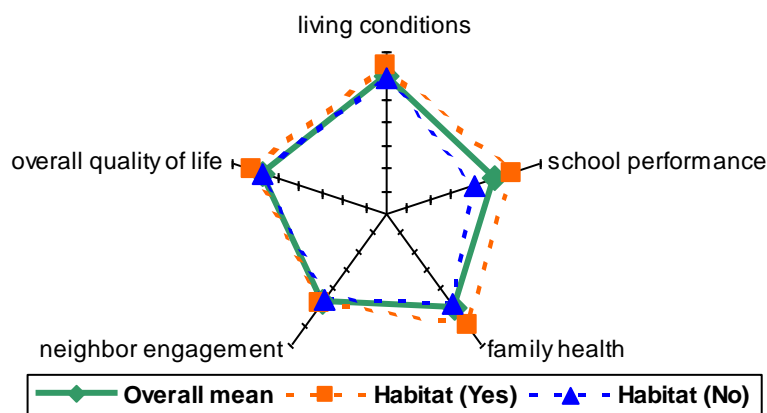
**Perceived improvement of quality of life:**

Table II-8 shows respondents' disagreement or agreement with each statement about the improvement in their quality of life since becoming a resident of a LEED-certified home. The aspect of quality of life with the highest mean value was "my living conditions have improved" (mean=6.0), the second highest was "overall my quality of life has been improved" (mean=5.7), and the third highest was "the health of members of my household has improved" (mean=5.1). The aspect of quality of life with the lowest value was "I become more engaged with my neighbors" (mean=4.7), and the second lowest was "my children's school performance has improved" (mean=4.9).

The mean values for the agreement with how much residents' quality of life has improved were compared between the Habitat and non-Habitat groups (table II-8). Mean values for all five aspects in the Habitat group were higher than those in the non-Habitat group. This result also illustrates the potential differences in the changes of their quality of life since they took ownership of LEED-certified homes. Households of the Habitat group tended to perceive the changes of their quality of life more strongly compared with the households of non-Habitat group. This result reflects a similar understanding about Habitat for Humanity homes and households as illustrated in the interview part of Section I-2. Yet interestingly, respondents in the Habitat group ranked lowest the item, "becoming friends with neighbors," whereas the respondents in the non-Habitat group ranked lowest the item, "children's school performance improved."

**Table II - 8. Level of agreement with quality of life since moved in LEED certified home**

		Overall							Total N	Mean (S.D.)	Habitat (Yes=33) Mean (S.D.)	Habitat (No=175) Mean (S.D.)
		Strongly Disagree	2	3	4	5	6	Strongly Agree				
My living conditions have improved	Frequency	1	4	5	21	29	55	106	221	6.00 (1.27)	6.41 (1.16)	5.88 (1.27)
	Percent	0.5%	1.8%	2.3%	9.5%	13.1%	24.9%	48.0%				
My child(ren)'s school performance has improved	Frequency	5	2	2	13	7	12	13	54	4.91 (1.86)	5.74 (1.26)	4.00 (2.04)
	Percent	9.3%	3.7%	3.7%	24.1%	13.0%	22.2%	24.1%				
Health of members of my household has improved	Frequency	12	6	7	55	32	41	52	205	5.05 (1.68)	5.97 (1.45)	4.84 (1.60)
	Percent	5.9%	2.9%	3.4%	26.8%	15.6%	20.0%	25.4%				
Become more engaged with my neighbors	Frequency	16	11	20	38	44	39	34	202	4.66 (1.76)	4.87 (1.61)	4.59 (1.82)
	Percent	7.9%	5.4%	9.9%	18.8%	21.8%	19.3%	16.8%				
Overall my quality of life has been improved	Frequency	6	5	6	20	46	64	78	225	5.66 (1.44)	6.06 (1.24)	5.58 (1.43)
	Percent	2.7%	2.2%	2.7%	8.9%	20.4%	28.4%	34.7%				



### **Perception of indoor environmental quality:**

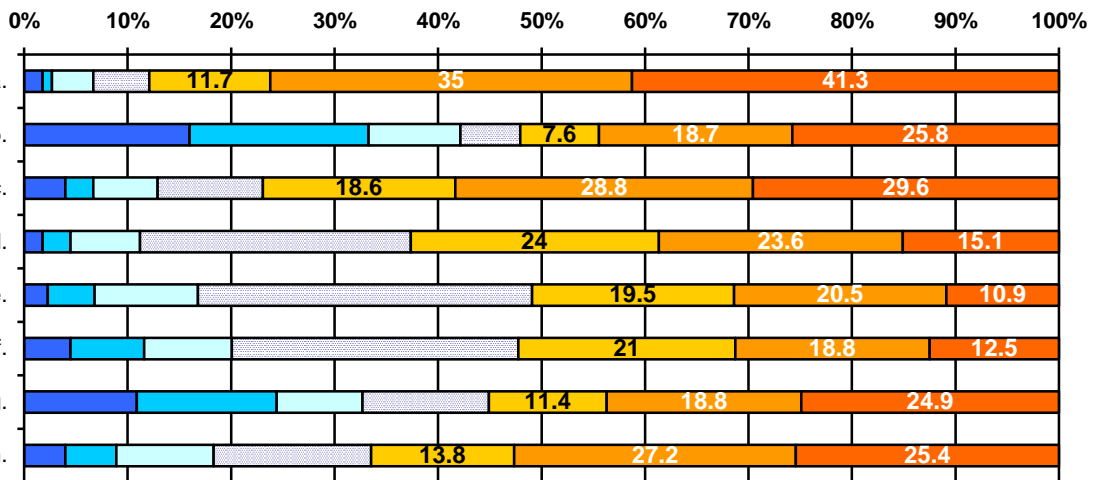
Respondents were asked to indicate the appropriate number between each pair of opposite descriptors on each aspect of indoor environment (i.e., uncomfortable vs. comfortable; unsafe vs. safe; unpleasant vs. pleasant; inconvenient vs. convenient; unsanitary vs. sanitary; unhealthy vs. healthy). Table II-9 shows how the residents in LEED-certified homes perceived the following aspects: (a) approximately 88% of the respondents perceived the “air quality” as fresh, whose rate is higher than 4 (neutral point); (b) about 52.1% of the respondents perceived the “air smell” as pleasant; (c) about 77% of the respondents perceived the “air movement” as circulating; (d) about 56.2% of the respondents perceived the “humidity” as neutral (ratings between 3 and 5); (e) slightly more than half of the respondent perceived the “temperature” as neutral (neither cold nor hot) in summer (=61.8%) and in winter(57.2%); (f) about 55.1% of the respondents perceived the “lighting quality” as comfortable; and (g) about 66.4% of the respondents perceived the “acoustic quality” as quiet.

### **Housing perception:**

Respondents were asked to indicate the appropriate number between each pair of opposite descriptions on their perceptions about their LEED-certified home. Table II-10 shows how survey participants perceived their home: (a) approximately 93.4% of the respondents felt comfortable about their LEED-certified home, whose rate is higher than 4 (neutral point); (b) about 95.6% of the respondents felt their home is attractive; (c) about 89.9% of the respondents felt their home is safe; (d) about 95.2% of the respondents felt pleasant in their home; (e) about 93.9% of the respondents felt their home is convenient; (f) approximately 86.2% of the respondents felt their home is stimulating; (g) about 95.5% of the respondents felt their home is sanitary; (h) approximately 94.3% of the respondents felt their home is healthy; and (i) 94.2% of the respondents felt their home is sustainable.

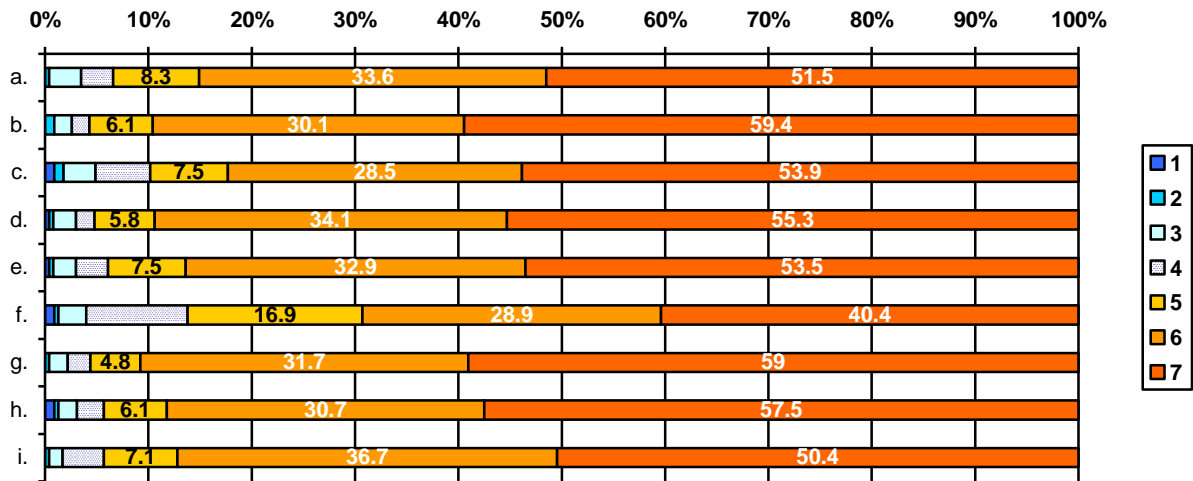
**Table II - 9. Indoor environment quality**

		1	2	3	4	5	6	7	Total N
a. Air Quality (1=Stale to 7=Fresh)	Frequency	4	2	9	12	26	78	92	223
	Percent	1.8%	0.9%	4.0%	5.4%	11.7%	35.0%	41.3%	
b. Air Smell (1=Unpleasant to 7=Pleasant)	Frequency	36	39	20	13	17	42	58	225
	Percent	16.0%	17.3%	8.9%	5.8%	7.6%	18.7%	25.8%	
c. Air Movement (1=Still to 7=Circulating)	Frequency	9	6	14	23	42	65	67	226
	Percent	4.0%	2.7%	6.2%	10.2%	18.6%	28.8%	29.6%	
d. Humidity (1=Humid to 7=Dry)	Frequency	4	6	15	59	54	53	34	225
	Percent	1.8%	2.7%	6.7%	26.2%	24.0%	23.6%	15.1%	
e. Temperature (Summer) (1=Hot to 7=Cold)	Frequency	5	10	22	71	43	45	24	220
	Percent	2.3%	4.5%	10.0%	32.3%	19.5%	20.5%	10.9%	
f. Temperature (Winter) (1=Cold to 7=Hot)	Frequency	10	16	19	62	47	42	28	224
	Percent	4.5%	7.1%	8.5%	27.7%	21.0%	18.8%	12.5%	
g. Lighting Quality (1=Uncomfortable to 7=Comfortable)	Frequency	25	31	19	28	26	43	57	229
	Percent	10.9%	13.5%	8.3%	12.2%	11.4%	18.8%	24.9%	
h. Acoustic Quality (1=Noisy to 7=Quiet)	Frequency	9	11	21	34	31	61	57	224
	Percent	4.0%	4.9%	9.4%	15.2%	13.8%	27.2%	25.4%	



**Table II - 10. Housing Perception**

		1	2	3	4	5	6	7	Total N
a. 1=Uncomfortable to 7= Comfortable	Frequency Percent	0 0.0%	1 0.4%	7 3.1%	7 3.1%	19 8.3%	77 33.6%	118 51.5%	229
b. 1=Unattractive to 7=Attractive	Frequency Percent	0 0.0%	2 0.9%	4 1.7%	4 1.7%	14 6.1%	69 30.1%	136 59.4%	229
c. 1=Unsafe to 7=Safe	Frequency Percent	2 0.9%	2 0.9%	7 3.1%	12 5.3%	17 7.5%	65 28.5%	123 53.9%	228
d. 1=Unpleasant to 7=Pleasant	Frequency Percent	1 0.4%	1 0.4%	5 2.2%	4 1.8%	13 5.8%	77 34.1%	125 55.3%	226
e. 1=Inconvenient to 7=Convenient	Frequency Percent	1 0.4%	1 0.4%	5 2.2%	7 3.1%	17 7.5%	75 32.9%	122 53.5%	228
f. 1=Not stimulating to 7=Stimulating	Frequency Percent	2 0.9%	1 0.4%	6 2.7%	22 9.8%	38 16.9%	65 28.9%	91 40.4%	225
g. 1=Unsanitary to 7=Sanitary	Frequency Percent	0 0.0%	1 0.4%	4 1.8%	5 2.2%	11 4.8%	72 31.7%	134 59.0%	227
h. 1=Unhealthy to 7=Healthy	Frequency Percent	2 0.9%	1 .4%	4 1.8%	6 2.6%	14 6.1%	70 30.7%	131 57.5%	228
i. 1=Unsustainable to 7=Sustainable	Frequency Percent	0 0.0%	1 0.4%	3 1.3%	9 4.0%	16 7.1%	83 36.7%	114 50.4%	226



## II-3 FAMILY'S WELL-BEING

The well-being of participants' families was investigated in five categories:

- Information about smoking and pets in the home
- Emotional health conditions in the home
- Physical health conditions in the home
- Perceived effectiveness of the indoor environment on respiratory symptoms
- Perceived factors influencing respiratory symptoms

### Information about smoking and pets at home:

Table II-11 shows information about smoking and pets at home. About three-quarters of the respondents had no smokers (75.1%), but others had one (21.8%) or two (3.1%) smokers. About 45.5% of the respondents replied no one was allowed to smoke inside the home, yet about 54.5% of the respondents replied that smoking was allowed inside the home. About 32.7% smoked 1 to 5 cigarettes per day, 34.6% smoked 6 to 10, 15.4% smoked 11 to 15, 13.5% smoked 16 to 20, and 3.8% of them smoked more than 20 cigarettes per day. About 23.6% of the respondents had 1 to 3 dogs, and approximately 13.2% of the respondents had 1 to 5 cats.

**Table II - 11. Information about smoking and pets at home**

Category	Frequency	Percent
<b>No. of people smoking at home (N=225)</b>		
No one	169	75.1
1 person	49	21.8
2 people	7	3.1
<b>Allow of smoking inside home (N=55)</b>		
No one is allowed to smoke anywhere inside my home	25	45.5
Smoking is allowed in some rooms or at some times	18	32.7
Smoking is permitted anywhere inside my home	12	21.8
<b>How many cigarettes per day (N=52)</b>		
1-5	17	32.7
6-10	18	34.6
11-15	8	15.4
16-20	7	13.5
More than 20	2	3.8
<b>How many dogs at home (N=207)</b>		
No dog	158	76.3
1 dog	39	18.8
2 dogs	9	4.3
3 dogs	1	0.5
<b>How many cats at home (N=196)</b>		
No cat	170	86.7
1 cat	14	7.1
2 cats	10	5.1
3 cats	1	0.5
5 cats	1	0.5

**Emotional health conditions:**

The emotional issues were anxiety, depression, stress, lack of confidence and motivation, and low energy. The results depended on the numbers of people reporting such emotional issues and on the reported increase or decrease of such symptoms (see Table II-12).

**Table II - 12. Emotional health conditions at home**

Problem	Number of people living in your home with this emotional issue		Thinking about the person living in your LEED certified home for whom this issue is the biggest problem:	
	# children (under 18 years old)	# adults (18 years and up)	In the past four weeks, how many days did this issue interfere with this household member's normal activities?	Do you think the number of days this problem interferes with the household members normal activities has increased, decreased or stayed about the same since you moved into your LEED home?
Anxiety	0 child (n=45) 1 child (n=8) 2 children (n=1)	0 adult (n=106) 1 adult (n=58) 2 adults (n=9) 3 adults (n=2)	0 day (n=17) 1-5 days (n=17) 6-10 days (n=3) 11-20 days (n=4) 21-30 days (n=10)	Increased (n=5) Decreased (n=27) Stayed about the same (n=37)
Depression	0 child (n=44) 1 child (n=5)	0 adult (n=107) 1 adult (n=61) 2 adults (n=5) 4 adults (n=1)	0 day (n=14) 1-5 days (n=8) 6-10 days (n=11) 11-20 days (n=2) 21-30 days (n=16)	Increased (n=9) Decreased (n=22) Stayed about the same (n=23)
Stress	0 child (n=40) 1 child (n=5) 2 children (n=2)	0 adult (n=88) 1 adult (n=68) 2 adults (n=22) 3 adults (n=2) 4 adults (n=1)	0 day (n=17) 1-5 days (n=18) 6-10 days (n=6) 11-20 days (n=10) 21-30 days (n=11)	Increased (n=19) Decreased (n=35) Stayed about the same (n=38)
Lack of confidence	0 child (n=44) 1 child (n=5) 2 children (n=1)	0 adult (n=122) 1 adult (n=43) 2 adults (n=1) 3 adults (n=1)	0 day (n=7) 1-5 days (n=10) 6-10 days (n=5) 11-20 days (n=2) 21-30 days (n=11)	Increased (n=14) Decreased (n=12) Stayed about the same (n=20)
Lack of motivation	0 child (n=44) 1 child (n=3)	0 adult (n=118) 1 adult (n=46) 2 adults (n=5)	0 day (n=6) 1-5 days (n=7) 6-10 days (n=5) 11-20 days (n=5) 21-30 days (n=12)	Increased (n=13) Decreased (n=12) Stayed about the same (n=26)
Low energy level	0 child (n=44) 1 child (n=1)	0 adult (n=102) 1 adult (n=63) 2 adults (n=9) 8 adults (n=1)	0 day (n=9) 1-5 days (n=12) 6-10 days (n=9) 11-20 days (n=5) 21-30 days (n=14)	Increased (n=17) Decreased (n=19) Stayed about the same (n=33)
Other : (adult: n=7) Conelout pain level 4-7 / Hip replacements / My lower back / No sex drive / PTSD / Thoughts of suicide / Very upsetting pet issue			0 day (n=0) 1-5 days (n=2) 6-10 days (n=1) 11-20 days (n=0) 21-30 days (n=2)	Increased (n=4) Decreased (n=0) Stayed about the same (n=1)



**Table II - 13. Physical health conditions at home**

Problem	Number of people living in your home with this health issue		Thinking about the person living in your LEED certified home for whom this issue is the biggest problem:	
	# children (under 18 years old)	# adults (18 years and up)	In the past four weeks, how many days did this issue interfere with this household member's normal activities?	Do you think the number of days this issue interferes with this household member's normal activities has increased, decreased or stayed about the same since you moved in to your LEED home?
Asthma	0 child (n=32) 1 child (n=9) 2 children (n=3)	0 adult (n=120) 1 adult (n=32) 2 adults (n=3) 3 adults (n=1)	0 day (n=18) 1-5 days (n=6) 6-10 days (n=1) 11-20 days (n=0) 21-30 days (n=4)	Increased (n=2) Decreased (n=18) Stayed about the same (n=19)
Respiratory allergies	0 child (n=37) 1 child (n=5) 2 children (n=4)	0 adult (n=102) 1 adult (n=50) 2 adults (n=6) 3 adults (n=2)	0 day (n=18) 1-5 days (n=9) 6-10 days (n=4) 11-20 days (n=2) 21-30 days (n=7)	Increased (n=6) Decreased (n=19) Stayed about the same (n=34)
Sensitivities to chemicals	0 child (n=40) 1 child (n=1) 2 children (n=1)	0 adult (n=116) 1 adult (n=35) 2 adults (n=2)	0 day (n=15) 1-5 days (n=0) 6-10 days (n=0) 11-20 days (n=0) 21-30 days (n=4)	Increased (n=2) Decreased (n=12) Stayed about the same (n=21)
Other breathing difficulty : (child: n=1, adult: n=25) Apnea / Bronchitis / COPD, emphysema (n=6) / Cor pulmonale / CORD / Deviated septum, chronic sinusitis / Dry sinuses / Lung disease / Nervousness / Sinus infections / smell when people smoke			0 day (n=7) 1-5 days (n=1) 6-10 days (n=1) 11-20 days (n=2) 21-30 days (n=4)	Increased (n=9) Decreased (n=8) Stayed about the same (n=7)
Hypertension	0 child (n=37) 1 child (n=1)	0 adult (n=110) 1 adult (n=45) 2 adults (n=6)	0 day (n=10) 1-5 days (n=3) 6-10 days (n=0) 11-20 days (n=1) 21-30 days (n=4)	Increased (n=3) Decreased (n=6) Stayed about the same (n=37)
Cardiovascular diseases	0 child (n=40)	0 adult (n=124) 1 adult (n=22) 2 adults (n=4)	0 day (n=9) 1-5 days (n=0) 6-10 days (n=1) 11-20 days (n=0) 21-30 days (n=2)	Increased (n=1) Decreased (n=1) Stayed about the same (n=21)
Irritation-eyes/ nose/ throat/skin	0 child (n=36) 1 child (n=5) 2 children (n=1) 3 children (n=1)	0 adult (n=108) 1 adult (n=45) 2 adults (n=4) 4 adults (n=1)	0 day (n=9) 1-5 days (n=8) 6-10 days (n=2) 11-20 days (n=3) 21-30 days (n=5)	Increased (n=13) Decreased (n=8) Stayed about the same (n=22)

**Table II - 13. Physical health conditions at home (Continued)**

Problem	Number of people living in your home with this health issue		Thinking about the person living in your LEED certified home for whom this issue is the biggest problem:	
	# children (under 18 years old)	# adults (18 years and up)	In the past four weeks, how many days did this issue interfere with this household member's normal activities?	Do you think the number of days this issue interferes with this household member's normal activities has increased, decreased or stayed about the same since you moved in to your LEED home?
Headache/ Fatigue/ Dizziness	0 child (n=39) 1 child (n=3)	0 adult (n=102) 1 adult (n=47) 2 adults (n=6)	0 day (n=9) 1-5 days (n=16) 6-10 days (n=5) 11-20 days (n=4) 21-30 days (n=4)	Increased (n=10) Decreased (n=11) Stayed about the same (n=27)
Visual discomfort/ Eye strain	0 child (n=40)	0 adult (n=119) 1 adult (n=35) 2 adults (n=1) 3 adults (n=1)	0 day (n=4) 1-5 days (n=5) 6-10 days (n=3) 11-20 days (n=1) 21-30 days (n=6)	Increased (n=9) Decreased (n=3) Stayed about the same (n=20)
General physical discomfort	0 child (n=40)	0 adult (n=112) 1 adult (n=35) 2 adults (n=7)	0 day (n=5) 1-5 days (n=5) 6-10 days (n=3) 11-20 days (n=0) 21-30 days (n=13)	Increased (n=10) Decreased (n=4) Stayed about the same (n=23)
Other Health Issue : (child: n=1, adult: n=17) hip replacements / allergies / alzheimer's / asthma / back problem / bipolar / blindness / blood clot disorder / common colds / deaf, stroke / diabetes (n=2) / Fibromyalgia, PTSD, Kidney disease / heavy metals / overweight / pain / physical disability / stroke			0 day (n=0) 1-5 days (n=1) 6-10 days (n=1) 11-20 days (n=2) 21-30 days (n=5)	Increased (n=3) Decreased (n=1) Stayed about the same (n=9)

**Physical health condition:**

The physical health issues were asthma, respiratory allergies, sensitivities to chemicals, breathing difficulty, hypertension, cardiovascular diseases, irritation to eyes/nose/throat/skin, headache/fatigue/dizziness, visual discomfort/eyestrain, and general physical discomfort. The results depended on the number of people reporting such physical issues and on the reported increase or decrease of such symptoms (see Table II-13).

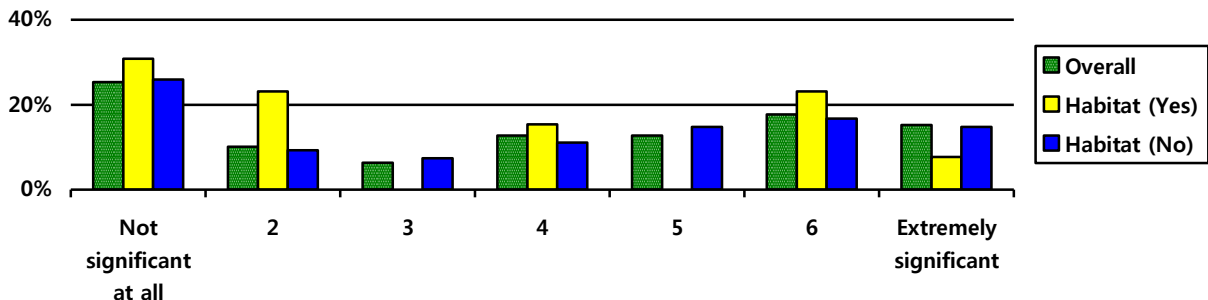
**The perceived effects of the indoor environment on respiratory symptoms:**

The survey participants were asked to rate the following question, “how insignificant or significant do you think the indoor environment is to triggering household members’ respiratory symptoms such as asthma, respiratory allergies, or sensitivity to chemicals?” Among 79 respondents for this question, about 45.6% indicated indoor environment affects respiratory symptoms (see Table II-14).

The mean score for the perceived effects of the indoor environment on respiratory symptoms was compared between the Habitat and non-Habitat groups (table II-14). Mean value of perceived effects of indoor environment was lower for the Habitat group (mean=3.31) than Non-Habitat group (mean=3.89). Although the mean differences between the two groups were not statistically significant, these results illustrated the potential differences between the two group in perceived effects of indoor environment. About 53.9% of the respondents in the Habitat group perceived indoor environment as a less or not significant factor to their respiratory symptoms, while 42.6% of the respondents in the Non-Habitat group perceived indoor environment as less or not significant factor. This difference may be because residents of households in the Habitat group may not have known whether or why their health conditions had changed. They may not associate their respiratory symptoms with indoor environmental quality.

**Table II - 14. Perceived effects of the indoor environment on respiratory symptoms**

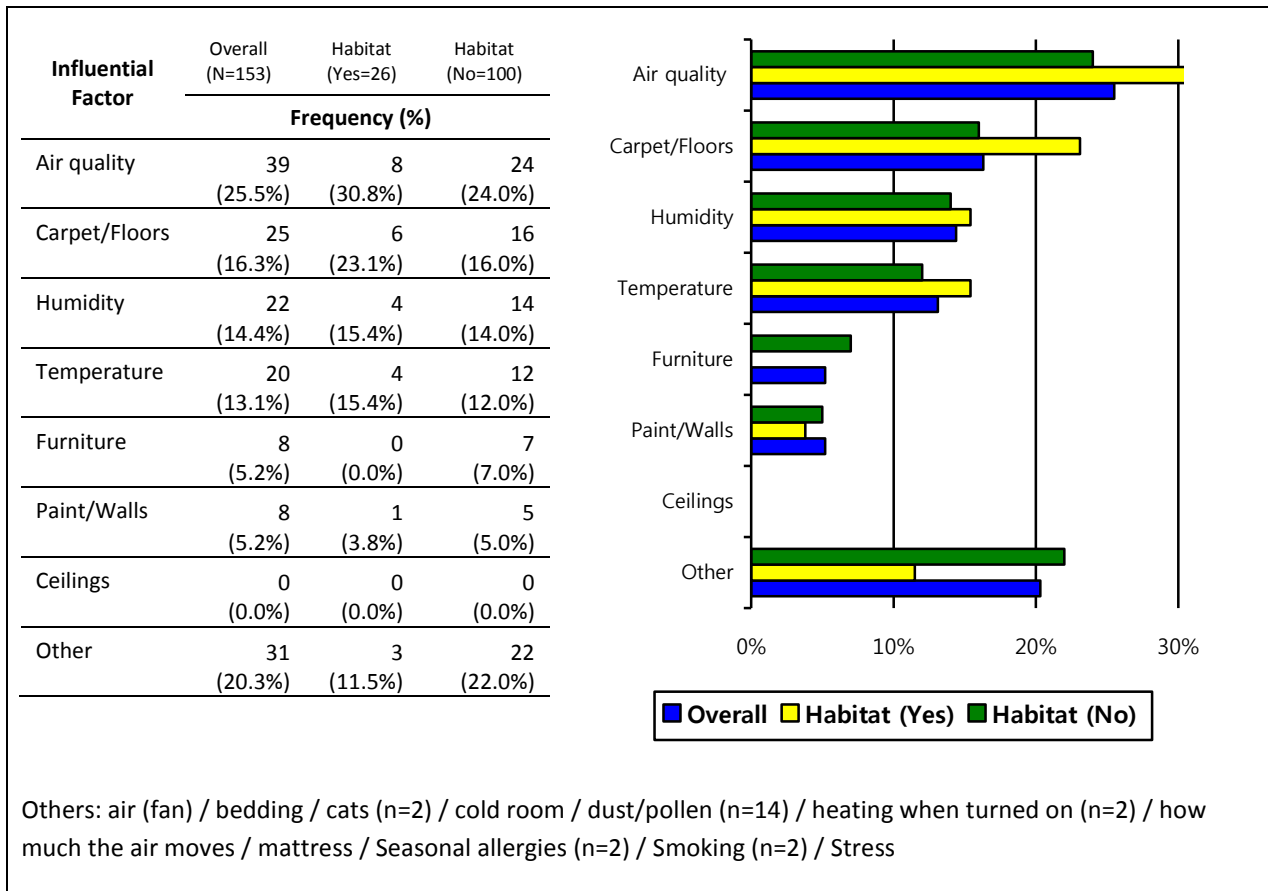
	Not significant at all	2	3	4	5	6	Extremely significant	N	Mean	Standard Deviation
	Frequency (%)									
Overall	20 (25.3%)	8 (10.1%)	5 (6.3%)	10 (12.7%)	10 (12.7%)	14 (17.7%)	12 (15.2%)	79	3.91	2.24
Habitat (Yes)	4 (30.8%)	3 (23.1%)	0 (0%)	2 (15.4%)	0 (0%)	3 (23.1%)	1 (7.7%)	13	3.31	2.29
Habitat (No)	14 (25.9%)	5 (9.3%)	4 (7.4%)	6 (11.1%)	8 (14.8%)	9 (16.7%)	8 (14.8%)	54	3.89	2.24



**Perceived factors influencing respiratory symptoms:**

Table II-15 shows respondents' opinions to the question, "Which, if any, aspects of the indoor environment trigger household members' respiratory symptoms?" Among seven indoor environmental factors, "air quality" was perceived as the most influential (25.5%) followed by "carpet/floors" (16.3%), "humidity" (14.4%), "temperature" (13.1%), "furniture" (5.2%), and "paint/walls" (5.2%). Households from the Habitat group perceived "air quality," "carpet/floors," humidity," and "temperature" as having the most effects on respiratory symptoms.

**Table II - 15. Perceived factors influencing respiratory symptoms**



## II-4 ENERGY EFFICIENCY

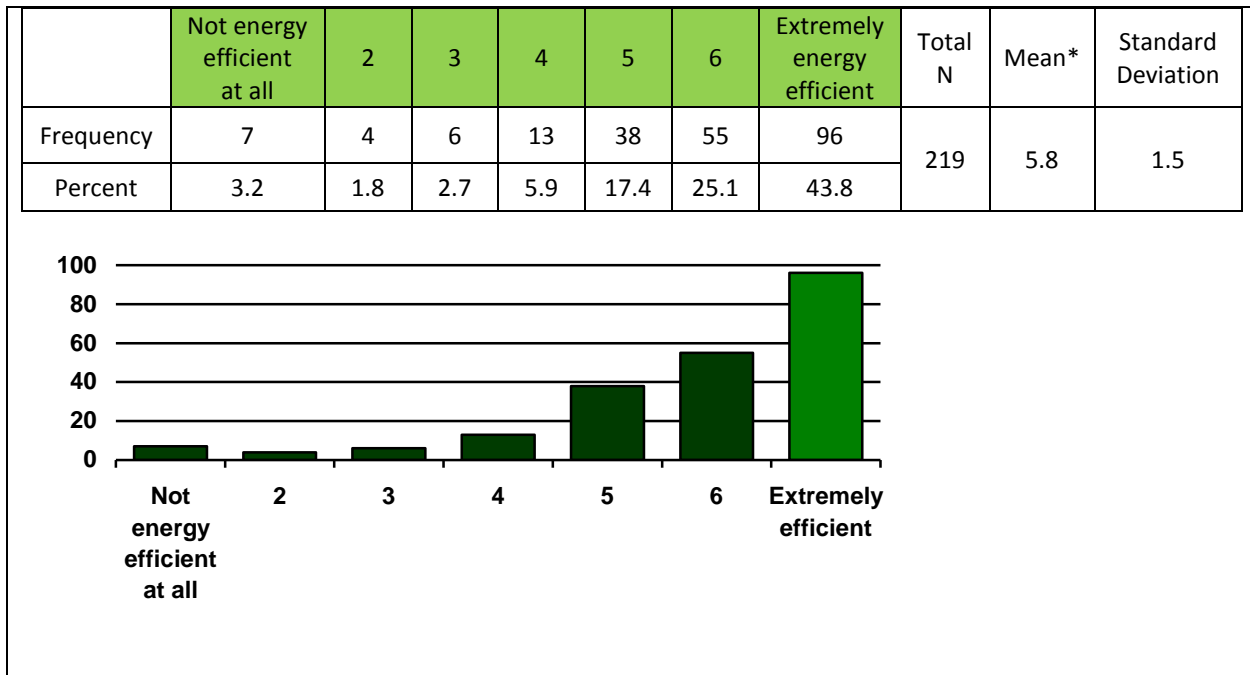
Perception of energy efficiency and actual use of energy were investigated. This section includes:

- Perceived energy efficiency
- Energy usage at home
- Water and energy cost
- Satisfaction with energy efficiency in relation to home characteristics
- Satisfaction with building performance in relation to housing characteristics
- Informed level of building features in relation to home characteristics

### Perceived energy efficiency:

About 86.3% of 219 respondents rated their home as energy efficient while only 7.7% of the respondents rated their home as inefficient. About 43.8% rated their home as “extremely energy efficient.” The mean value of the perceived energy efficiency level was 5.8 out of 7, which indicated most residents perceived their homes as energy-efficient (table II-16).

**Table II - 16. Perceived level of energy efficiency**



\* Mean was computed based on 7 point Likert scale, 1=Not energy efficient at all to 7=Extremely energy efficient.

To examine if the perceived energy efficiency depends on housing conditions, mean differences of the perceived energy-efficiency between Habitat vs. non-Habitat, homeowner vs. renter, and 4 LEED rating levels were examined through one-way ANOVA tests. *F*-values with significant *p*-values represents significant mean value differences between the respondent groups. When the *p*-values are lower than 0.05, the means are statistically different across the comparison groups.

Table II-17 shows that mean value difference of perceived energy efficiency between homeowners and renters was statistically significant ( $F=2.72, p<.01$ ). In addition, the mean value difference among resident groups living in platinum, gold, and silver LEED certified homes was statistically significant ( $F=3.39, p<.05$ ). Yet, there was no significant mean difference between the Habitat and Non-Habitat groups. This result demonstrated the perceived level of energy efficiency was significantly related to homeownership and to the level of LEED certification. Although the perceived levels of energy efficiency between Habitat and Non-Habitat groups were not statistically significant, even slight mean differences suggested that the Habitat residents were more likely to perceive their homes as energy-efficient than the non-Habitat group did.

**Table II - 17. Mean differences in perceived level of energy efficiency depending on home characteristics**

Perceived level of energy efficiency		Mean*	Standard Deviation	<i>F</i> -value	<i>p</i> -value
Ownership (N=207)	Own home (n=105)	6.09	1.09	2.72	0.007 <sup>a</sup>
	Rent home (n=102)	5.53	1.78		
LEED rate (N=126)	Platinum (n=32)	6.13	1.26	3.39	0.020 <sup>b</sup>
	Gold (n=29)	6.21	1.26		
	Silver (n=46)	6.00	1.10		
	Certified (n=19)	5.05	1.99		
Habitat for Humanity (N=194)	Yes (n=29)	5.93	1.44	0.65	0.518
	No (n=165)	5.73	1.53		

The figure consists of three horizontal bar charts. The first chart, titled 'perceived level of energy efficiency by home ownership', shows an overall mean of 5.83 (dark green bar). Individual bars for 'own' (6.09, light green) and 'rent' (5.53, yellow) are shown. The second chart, 'perceived level of energy efficiency by LEED rate', shows an overall mean of 5.83 (dark green bar). Individual bars for 'platinum' (6.13, light green), 'gold' (6.21, yellow), 'silver' (6.00, grey), and 'certified' (5.05, orange) are shown. The third chart, 'perceived level of energy efficiency by built-by-Habitat', shows an overall mean of 5.83 (dark green bar). Individual bars for 'Yes' (5.93, light green) and 'No' (5.73, yellow) are shown.

\* Mean was computed based on 7 point Likert scale, 1=Not energy efficient at all to 7=Extremely energy efficient.

<sup>a</sup> Statistically significant at 99% level ( $p<.01$ )

<sup>b</sup> Statistically significant at 95% level ( $p<.05$ )

**Table II - 18. Energy usage at home**

	Frequency	Percent
<b>Thermostat set during summer (N=231)</b>		
60-65F	22	9.5
66-70	110	47.6
71-75	87	37.7
76-80	12	5.2
<b>Thermostat set during winter (N=197)</b>		
60 or below	33	16.8
61-65	10	5.1
66-70	55	27.9
71-75	73	37.1
76-80	26	13.2
<b>How many supplement heaters (N=219)</b>		
0	181	82.6
1	32	14.6
2	5	2.3
6	1	.5
<b>How many televisions (N=232)</b>		
0	7	3.0
1	69	29.7
2	83	35.8
3	40	17.2
4	19	8.2
5	8	3.4
More than 5	6	2.6
<b>How many hours TVs on (N=221)</b>		
0 hour	3	1.4
1-5 hours	130	58.8
6-10 hours	62	28.1
11-15 hours	12	5.4
16-20 hours	7	3.2
21-24 hours	7	3.2
<b>Does your home have...(N=235)</b>		
permanent swimming pool	4	1.7
hot tub	15	6.4
in-ground sprinkler system	94	40.0
<b>How often do you water lawn during summer (N=209)</b>		
Daily	20	9.6
A few times a week	51	24.4
Once a week	18	8.6
Less than once a week	32	15.3
Never	88	42.1

## Satisfaction with energy efficiency

Tables II-18 and II-19 show how households used the thermostat, heaters, and TVs, and how much the respondents paid for water, gas, and energy.

**Table II - 19. Water and energy bills**

	<b>Bills (\$)</b>	<b>Winter Frequency (%)</b>	<b>Summer Frequency (%)</b>	<b>Energy saving Frequency (%)</b>
<b>Water</b>	\$0	30 (28.6%)	28 (27.5%)	33 (54.1%)
	\$1-20	14 (13.3%)	10 (9.8%)	16 (26.2%)
	\$21-40	29 (27.6%)	22 (21.6%)	5 (8.2%)
	\$41-60	7 (6.7%)	13 (12.7%)	3 (4.9%)
	\$61-80	8 (7.6%)	6 (5.9%)	2 (3.3%)
	\$81-100	3 (2.9%)	8 (7.8%)	1 (1.6%)
	\$101-200	11 (10.5%)	11 (10.8%)	0 (0%)
	\$201-400	3 (2.9%)	4 (3.9%)	1 (1.6%)
	Over \$400	0 (0%)	1(1.0%)	0 (0%)
	<b>Total N</b>	<b>105</b>	<b>102</b>	<b>61</b>
<b>Electricity</b>	\$0	9 (5.7%)	8 (5.1%)	20 (19.6%)
	\$1-20	3 (1.9%)	5 (3.2%)	19 (18.6%)
	\$21-40	17 (10.8%)	32 (20.4%)	20 (19.6%)
	\$41-60	33 (20.9%)	27 (17.2%)	17 (16.7%)
	\$61-80	22 (13.9%)	25 (15.9%)	4 (3.9%)
	\$81-100	17 (10.8%)	13 (8.3%)	16 (15.7%)
	\$101-200	41 (25.9%)	35 (22.3%)	6 (5.9%)
	\$201-400	11 (7.0%)	9 (5.7%)	0 (0%)
	Over \$400	5 (3.2%)	3 (1.9%)	0 (0%)
	<b>Total N</b>	<b>158</b>	<b>157</b>	<b>102</b>
<b>Gas/ Heating</b>	\$0	20 (14.6%)	25 (18.8%)	17 (20.0%)
	\$1-20	8 (5.8%)	29 (21.8%)	8 (9.4%)
	\$21-40	20 (14.6%)	44 (33.1%)	14 (16.5%)
	\$41-60	25 (18.2%)	17 (12.8%)	11 (12.9%)
	\$61-80	21 (15.3%)	6 (4.5%)	5 (5.9%)
	\$81-100	15 (10.9%)	3 (2.3%)	10 (11.8%)
	\$101-200	22 (16.1%)	8 (6.0%)	11 (12.9%)
	\$201-400	5 (3.6%)	1 (0.8%)	8 (9.4%)
	Over \$400	1 (0.7%)	0 (0%)	1 (1.2%)
	<b>Total N</b>	<b>137</b>	<b>133</b>	<b>85</b>



Table II-20 shows the respondents' satisfaction with efficiency of water, electricity, and gas usage. Survey participants were asked, “How dissatisfied or satisfied are you with the efficiency of each of the followings—water, electricity, and gas—in your LEED certified home?” The mean satisfaction level was calculated for each of water, electricity, and gas efficiency based on a 7-point scale, with 1 representing “very dissatisfied” and 7 representing “very satisfied.” The results showed respondents were quite satisfied with efficiencies of water (=5.93), electricity (=5.64), and gas or other heating fuel (=5.70).

A one-way ANOVA test revealed that homeownership ( $F=3.029, p<.05$ ) and LEED-ratings ( $F=2.703, p<.05$ ) seem to influence residents' satisfaction with the efficiency of gas. However, there was no mean difference in satisfaction level with water and electricity efficiency depending on respondents' housing characteristics (see also Table II-20).

**Table II - 20. Mean differences in satisfaction with energy efficiency depending on home characteristics**

Satisfaction with energy efficiency		water	electricity	gas/ heating fuel	
overall		N=222 Mean=5.93 S.D.=1.15	N=224 Mean=5.64 S.D.=1.54	N=196 Mean=5.70 S.D.=1.48	
ownership	own	n=109 Mean=5.85 S.D.=1.20	n=108 Mean=5.81 S.D.=1.25	n=96 Mean=6.03 S.D.=1.25	
	rent	n=100 Mean=5.98 S.D.=1.11	n=103 Mean=5.43 S.D.=1.81	n=90 Mean=5.39 S.D.=1.63	
	<i>F</i> -value	-0.791	1.821	3.029 <sup>a</sup>	
LEED rate	platinum	n=30 Mean=6.07 S.D.=1.28	n=30 Mean=5.79 S.D.=1.51	n=28 Mean=6.18 S.D.=1.28	
	gold	n=30 Mean=6.37 S.D.=0.72	n=30 Mean=6.23 S.D.=1.17	n=22 Mean=6.36 S.D.=0.85	
	silver	n=45 Mean=5.82 S.D.=1.01	n=44 Mean=5.70 S.D.=1.21	n=40 Mean=5.95 S.D.=1.15	
	certified	n=19 Mean=5.95 S.D.=1.31	n=21 Mean=5.52 S.D.=1.91	n=19 Mean=5.32 S.D.=1.73	
	<i>F</i> -value	1.594	1.322	2.703 <sup>a</sup>	
Habitat for humanity	yes	n=33 Mean=5.70 S.D.=1.53	n=33 Mean=5.91 S.D.=1.49	n=32 Mean=5.97 S.D.=1.31	
	no	n=166 Mean=5.95 S.D.=1.06	n=166 Mean=5.56 S.D.=1.53	n=145 Mean=5.62 S.D.=1.54	
	<i>F</i> -value	-1.133	1.201	1.186	

\* Mean was computed based on 7 point Likert sale, 1=Very Dissatisfied to 7=Very satisfied.

<sup>a</sup> Statistically significant at 95% level ( $p<.05$ )

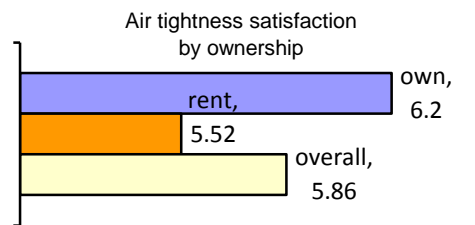
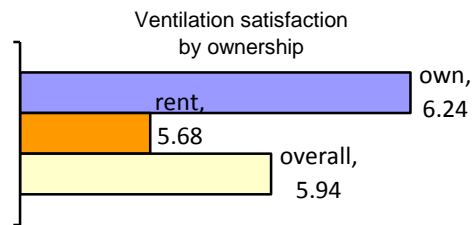
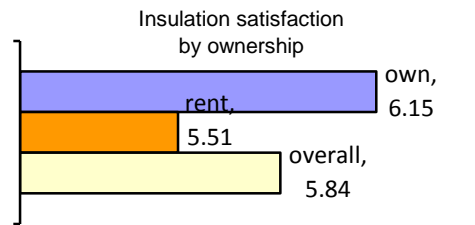
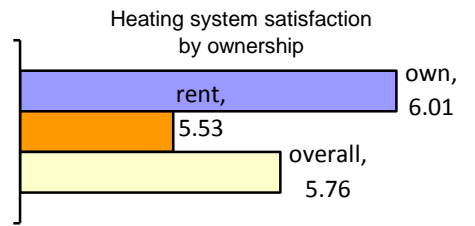
### **Satisfaction with building performance**

Survey participants were asked to indicate “How dissatisfied or satisfied are you with the performances and effectiveness of each of the 16 building features?” Mean values for their satisfaction levels in building performances were calculated. As Table II-21 shows, the most satisfactory of the 16 features were “efficient toilets” (mean=6.10), “electrical lighting” (mean=6.08), “faucets” (mean=6.07), and “hot water supply” (mean=6.05). The least satisfactory feature was “wind power” (mean=5.35), followed by “solar energy systems” (mean=5.67), “windows and doors” (mean=5.68), “heating system” (mean=5.76), and “insulation” (mean=5.84).

Table II-21 shows the results of a one-way ANOVA tests to verify if the satisfaction with each of the building performance items depends on the housing tenure. The satisfaction with the performance of heating system ( $F=2.16, p<.05$ ), insulation ( $F=2.92, p<.05$ ), ventilation ( $F=3.08, p<.05$ ), and air tightness ( $F=3.34, p<.01$ ) differed between homeowners and renters. In other words, homeownership seems to have significant relationships with residents' satisfaction with heating, insulation, ventilation, and air tightness.

**Table II - 21. Mean differences in satisfaction level of home feature performance depending on home ownership**

Performance of Home feature	Ownership		F-value
	Own	Rent	
Heating system N=229 Overall mean*=5.76 S.D.=1.65	n=110 Mean=6.01 S.D.=1.28	n=107 Mean=5.53 S.D.=1.92	2.16 <sup>b</sup>
Cooling system N=208 Overall mean=5.94 S.D.=1.51	n=92 Mean=5.79 S.D.=1.60	n=104 Mean=6.07 S.D.=1.43	-1.27
Hot water supply N=230 Overall mean=6.05 S.D.=1.32	n=110 Mean=6.15 S.D.=1.25	n=108 Mean=5.91 S.D.=1.41	1.37
Electrical Lighting N=228 Overall mean=6.08 S.D.=1.24	n=110 Mean=6.14 S.D.=1.27	n=106 Mean=6.01 S.D.=1.25	0.74
Insulation N=225 Overall mean=5.84 S.D.=1.63	n=110 Mean=6.15 S.D.=1.32	n=104 Mean=5.51 S.D.=1.87	2.92 <sup>b</sup>
Ventilation N=228 Overall mean=5.94 S.D.=1.37	n=110 Mean=6.24 S.D.=1.09	n=106 Mean=5.68 S.D.=1.53	3.08 <sup>b</sup>
Air tightness N=218 Overall mean=5.86 S.D.=1.52	n=108 Mean=6.20 S.D.=1.20	n=99 Mean=5.52 S.D.=1.74	3.34 <sup>a</sup>
Appliances N=230 Overall mean=6.04 S.D.=1.27	n=110 Mean=5.90 S.D.=1.35	n=107 Mean=6.21 S.D.=1.11	-1.82
Windows & doors N=229 Overall mean=5.68 S.D.=1.58	n=110 Mean=5.70 S.D.=1.47	n=107 Mean=5.71 S.D.=1.61	-0.05
Window treatment N=197 Overall mean=5.94 S.D.=1.37	n=90 Mean=6.08 S.D.=1.24	n=97 Mean=5.80 S.D.=1.48	1.36
Toilets N=228 Overall mean=6.10 S.D.=1.24	n=110 Mean=6.08 S.D.=1.26	n=106 Mean=6.09 S.D.=1.25	-0.07
Faucets N=229 Overall mean=6.07 S.D.=1.27	n=108 Mean=6.02 S.D.=1.34	n=108 Mean=6.12 S.D.=1.24	-0.58
Showerheads N=228 Overall mean=6.01 S.D.=1.24	n=108 Mean=6.10 S.D.=1.23	n=107 Mean=5.92 S.D.=1.27	1.09
Solar energy system N=69 Overall mean=5.67 S.D.= 1.90	n=32 Mean=5.94 S.D.=1.54	n=32 Mean=5.50 S.D.=2.16	0.93
Wind power N=46 Overall mean=5.35 S.D.=2.09	n=13 Mean=5.15 S.D.=2.19	n=28 Mean=5.50 S.D.=2.06	-0.49
Water conservation systems N=92 Overall mean=5.97 S.D.=1.59	n=47 Mean=6.13 S.D.=1.44	n=38 Mean=5.89 S.D.=1.67	0.69



\* Mean was computed based on 7 point Likert scale, 1=Very Dissatisfied to 7=Very satisfied.

<sup>a</sup> Statistically significant at 99% level ( $p < .01$ ) (2-tailed)

<sup>b</sup> Statistically significant at 95% level ( $p < .05$ ) (2-tailed)

## Informed level of building system operation

Table II-22 shows the results of how well the residents understood building system operations. Survey participants were asked, “How well informed do you feel about using the following 16 building systems [shown as Table II-21] in your home?” The mean value of informed level was calculated on a 7-point scale, with 1 representing “not well informed at all” and 7 representing “extremely well informed.” Table II-22 shows the results of one-way ANOVA test to verify if the informed level depends on housing characteristics. Homeownership ( $F=2.46, p<.05$ ) and LEED rate ( $F=4.10, p<.01$ ) seemed to influence the perceived level of how well residents were informed about their home features. Although these levels between Habitat and non-Habitat groups were not statistically significant, the slightly different means illustrate that the households from the Habitat group were less informed about their home features than their counterparts were.

**Table II - 22. Mean differences in informed level of home features depending on home characteristics**

Informed level of home features		Mean*	Standard Deviation	F-value	p-value
Overall (N=228)		5.71	1.38	-	-
Ownership (N=216)	Own home (n=109)	5.94	1.11	2.46	0.015 <sup>b</sup>
	Rent home (n=107)	5.49	1.55		
LEED rate (N=127)	Platinum (n=33)	6.00	1.12	4.10	0.008 <sup>a</sup>
	Gold (n=30)	6.17	1.29		
	Silver (n=46)	5.98	0.95		
	Certified (n=18)	5.00	1.61		
Habitat for Humanity (N=202)	Yes (n=32)	5.53	1.63	-0.82	0.412
	No (n=170)	5.75	1.35		

\* Mean was computed based on 7 point Likert sale, 1=Not well informed at all to 7=Extremely well informed.

<sup>a</sup> Statistically significant at 99% level ( $p<.01$ )

<sup>b</sup> Statistically significant at 95% level ( $p<.05$ )

## II-5 ENVIRONMENTAL ATTITUDE & BEHAVIOR

The survey participants' environmental attitudes and behaviors were measured by multiple questions from two categories:

- Awareness of LEED-certification
- Pro-environmental activities

### Awareness of LEED- certification

Table II-23 shows the survey participants' attendance of relevant LEED home classes. Out of 228 respondents, approximately 12.3% indicated they or their family members had attended LEED classes. Table II-23 also shows the differences in class attendance between the Habitat and Non-Habitat groups. About 45.2% of the respondents from the Habitat group attended LEED classes while 8.1% from the Non-Habitat group did so. This difference in part can be attributed to differences in homeownership rates between the two groups. Twenty-six out of 33 respondents of the Habitat group (78.86%) were identified as homeowners. Eighty-four out of 175 respondents from the non-Habitat group were homeowners (48%).

**Table II - 23. Attendance of LEED classes and membership of conservation group**

		Frequency (%)	
		Yes	No
Attended LEED classes for homeowners?	Overall (N=228)	28 (12.3%)	200 (87.7%)
	Habitat group (N=31)	14 (45.2%)	17 (54.8%)
	Non-Habitat Group (N=172)	14 (8.1%)	158 (91.9%)
Member of environment conservation group?	Overall (N=228)	40 (17.5%)	188 (82.5%)
	Habitat group (N=32)	2 (6.3%)	30 (93.8%)
	Non-Habitat Group (N=172)	33 (19.2%)	139 (80.8%)

### Pro-environmental activities

Out of 228 respondents, about 17.5% indicated an affiliation with any environmental preservation or protection groups (see Table II-23). Habitat home households were less involved in environment conservation groups compared with the non-Habitat group.

Table II-24 shows the mean values of six pro-environmental activities and the results from a one-way ANOVA test for group comparison depending on housing conditions.

According to Table II-24, practices such as "using Energy Star appliances," "buying green home again," and "using recycled materials" differed between homeowners and renters. Resident attitude toward the use of environmentally friendly chemicals varied among LEED certification levels ( $F=4.098$ ,  $p<.01$ ). For buying organic fruits and vegetables and avoiding environmentally

irresponsible companies there were mean differences between the Habitat and non-Habitat groups. Interestingly, there were significant differences in all six items between the residents with and without membership in an environmental group.

**Table II - 24. Mean differences in pro-environmental activities by household characteristics**

Household activity		Using energy star appliance	Buying green home next	Using recycled materials	Using environment ally friendly chemicals	Buying organic fruits/vegies	Avoiding environment ally non-responsible company
overall		N=216 Mean=4.15 S.D.=1.18	N=209 Mean=3.86 S.D.=1.36	N=224 Mean=4.13 S.D.=1.11	N=228 Mean=4.11 S.D.=1.09	N=221 Mean=3.55 S.D.=1.39	N=226 Mean=3.93 S.D.=1.32
owners hip	own	n=107 Mean=4.60 S.D.=0.76	n=107 Mean=4.39 S.D.=0.98	n=108 Mean=4.43 S.D.=0.91	N=109 Mean=4.15 S.D.=1.03	N=107 Mean=3.73 S.D.=1.30	N=109 Mean=3.90 S.D.=1.22
	rent	n=99 Mean=3.71 S.D.=1.33	n=95 Mean=3.28 S.D.=1.45	n=106 Mean=3.84 S.D.=1.22	N=107 Mean=4.05 S.D.=1.14	N=103 Mean=3.41 S.D.=1.45	N=106 Mean=3.92 S.D.=1.42
	<i>F-value</i>	5.938 <sup>a</sup>	6.432 <sup>a</sup>	3.992 <sup>a</sup>	0.680	1.691	-0.141
LEED rate	platinum	n=32 Mean=4.44 S.D.=1.01	n=30 Mean=4.07 S.D.=1.44	n=33 Mean=4.42 S.D.=0.94	n=33 Mean=4.58 S.D.=0.71	n=31 Mean=3.87 S.D.=1.34	n=33 Mean=4.36 S.D.=1.06
	gold	n=28 Mean=4.68 S.D.=0.82	n=29 Mean=4.45 S.D.=1.02	n=29 Mean=4.55 S.D.=0.87	n=30 Mean=4.33 S.D.=1.03	n=29 Mean=4.07 S.D.=1.25	n=30 Mean=3.83 S.D.=1.34
	silver	n=47 Mean=4.23 S.D.=1.09	n=47 Mean=4.11 S.D.=1.22	n=47 Mean=4.09 S.D.=1.25	n=47 Mean=3.83 S.D.=1.26	n=47 Mean=3.51 S.D.=1.40	n=47 Mean=3.68 S.D.=1.39
	certified	n=18 Mean=3.89 S.D.=1.18	n=18 Mean=3.61 S.D.=1.34	n=20 Mean=3.85 S.D.=1.27	n=21 Mean=3.81 S.D.=1.17	n=20 Mean=3.15 S.D.=1.39	n=20 Mean=3.65 S.D.=1.50
	<i>F-value</i>	2.424	1.673	2.231	4.098 <sup>a</sup>	2.286	2.057
Habitat for humani ty	Habitat	n=32 Mean=4.19 S.D.=1.15	n=32 Mean=4.09 S.D.=1.33	n=32 Mean=4.13 S.D.=1.04	n=32 Mean=3.88 S.D.=1.10	n=30 Mean=3.00 S.D.=1.44	n=32 Mean=3.44 S.D.=1.44
	Non-Habitat	n=163 Mean=4.16 S.D.=1.21	n=157 Mean=3.83 S.D.=1.38	n=168 Mean=4.13 S.D.=1.17	n=171 Mean=4.11 S.D.=1.11	n=167 Mean=3.62 S.D.=1.39	n=170 Mean=3.95 S.D.=1.30
	<i>F-value</i>	0.232	0.977	0.0	-1.107	-2.246 <sup>b</sup>	-2.023 <sup>b</sup>
Conserv ation Membe rship	yes	n=38 Mean=4.84 S.D.=0.44	n=37 Mean=4.51 S.D.=0.77	n=39 Mean=4.79 S.D.=0.41	n=40 Mean=4.63 S.D.=0.71	n=39 Mean=4.23 S.D.=1.14	n=40 Mean=4.30 S.D.=0.99
	No	n=174 Mean=3.98 S.D.=1.25	n=168 Mean=3.74 S.D.=1.39	n=180 Mean=3.98 S.D.=1.17	n=183 Mean=3.99 S.D.=1.13	n=177 Mean=3.44 S.D.=1.39	n=182 Mean=3.83 S.D.=1.37
	<i>F-value</i>	4.186 <sup>a</sup>	3.272 <sup>a</sup>	4.270 <sup>a</sup>	3.394 <sup>a</sup>	3.339 <sup>a</sup>	2.049 <sup>b</sup>

\* Mean was computed based on 7 point Likert scale, 1=Not likely at all to 7=Extremely likely.

<sup>a</sup> Statistically significant at 99% level ( $p < .01$ )

<sup>b</sup> Statistically significant at 95% level ( $p < .05$ )

## RESULT DISSEMINATION

Findings from the survey and the case studies will be presented at local, national, and international planners' meetings, workshops and seminars, and also at local, national, and international conferences for homebuilding and design professionals and environmental research professionals. The research findings will further be disseminated via published articles in home magazines, trade journals, and academic journals.

## CONCLUSION & POLICY RECOMMENDATIONS

The findings of this study revealed that most residents of the LEED-certified home were satisfied with their home and their quality of life in their home. Residents in the Habitat for Humanity, in particular, were more satisfied with their homes and their quality of life than residents of Non-Habitat home were, although their satisfaction with their neighborhood and specific aspects of home environment (e.g., space layout, size of space, finishes, visual privacy, view, temperature, humidity) was lower than that of Non-Habitat residents. Residents of the Habitat for Humanity tended to perceive the improvement of their quality of life since moving into their LEED-certified home more strongly than residents of the Non-Habitat home did. They were also more satisfied with energy efficiency of their home than residents of the Non-Habitat home.

- **Promote sustainability in low-income housing:** Most of LEED-certified homes including Habitat for Humanity homes offered satisfactory indoor environmental quality and building performance to their residents. In particular, LEED-certified Habitat for Humanity homes greatly improved residents' satisfaction, positive perceptions of their environments, and their sense of well-being. These results shed a light on the necessity of enhancing green features in low-income houses to improve residential satisfaction and quality of life of low-income families.

Major findings strongly support the positive effects of green low-income homes on residents' behavioral, social, and psychological aspects of well-being. Stronger support and considerations should thus be added to developing more numbers of green Habitat for Humanity homes. Policy makers should understand this necessity and promote incentives or financial support for green low-income home development and supply.

More programs that can offer incentives for participation in LEED green building certification programs and increase funding opportunities to cover the initial costs of sustainable home building for low-income families at both state and local levels should be developed because those efforts will produce long-term economic and environmental benefits.

- **Improve the design of low-income green housing:** Architects, designers, engineers, contractors, and facility managers can gain greater understanding of design and the performance of low-income green homes with the findings of this POE project by receiving feedback for the future projects. Although the houses were LEED-certified, some problems in maintaining the green features, building performance, and comfortable home environment were identified. Architects, designers, engineers, green policy makers, and Habitat for Humanity Affiliates should pay attention to the specific needs relevant to these issues to improve the design quality of low-income green home through the process of planning, design, and construction.



- **Promote the POE:** More extensive implementation of POEs is critical. Since the LEED certification system is based on "as-designed" performance, further implementation of POEs is exceptionally important to verify actual performance and expected performance. It is anticipated that the small sampling from this project will provide a valuable glimpse into what might be learned from industry-wide adoption and implementation of the POE that can benefit sustainability and green building for lower income populations.

In particular, since there is no post-occupancy evaluation process included in the LEED-certifications or other green home certifications, there is no empirical data to verify whether these green homes perform satisfactorily in terms of heating, cooling, or indoor environmental quality. The finding that many residents did not remember the LEED certification level of their homes proved that post-occupancy follow-ups should be planned for the LEED-certified or other types of green homes. This will keep their green homes green without any critical issues.

- **Contribute to the general body of knowledge:** This POE project is expected to contribute to the knowledge of human health, indoor environmental quality, and sustainable housing design. Although there is a consensus about the benefits of green homes, few empirical studies about the actual effects of LEED-certified green homes on residents' health, comfort, and satisfaction have been conducted. The finding from this POE study therefore increased understanding of the benefits to be gained from LEED-certified low-income homes by applying empirically tested, research-based knowledge. This project provided empirical data from both intensive interviews and surveys and offered fundamental tools for POEs for future studies.
- **Promote public awareness:** This POE study will educate the public about the impact of LEED-certified homes on (1) improving the residential environmental quality and energy efficiency, (2) reducing residents' health risks and (3) enhancing residents' comfort and satisfaction by disseminating the results of this research at conferences and by publishing articles in scholarly and extension journals.
- **Make a Policy Recommendation:** Policy makers will compile a list of policy recommendations this research proposed to make Michigan more sustainable and profitable through greater economic and environmental benefits of low-income green homes by promoting more widespread adoption of green homes.
  - 1) Incentives for green homes, such as LEED-certified homes, Energy Star Homes, or National Association of Home Builders' Green certified homes, should be offered to developers, contractors, and homeowners. This will be critical for both new and existing homes located in the cold regions such as Michigan to encourage energy-efficient green home constructions for low-income families in order to offer lower utility bills.
  - 2) Policy makers should collaborate closely with local builders and developers to apply more green home features to new or existing low-income houses. Certain types of incentives for local builders and developers are desired.

3) Post-occupancy evaluations of green certified homes should be encouraged, particularly for low-income housing. Continuous efforts should be made to save energy and keep green homes energy-efficient for these households and homeowners.

4) We suggest conducting POEs of green certified homes in five or ten years to preserve their green features and energy efficiency. Based on the POEs, the homes may or may not be repaired to keep the original functions of green features. In the POEs and repairing process, local home remodeling companies can be involved. Some incentives should be considered for the local companies or businesses to be involved in this green process if they are small or micro businesses. Tax reductions for these types of companies (i.e., energy auditors, window replacement companies) can promote small entrepreneurs working on sustainable housing projects in local communities. This can create more local jobs.

5) We suggest offering regular educational seminars for residents of green certified homes in order to offer precise information about the green features of their homes and educate them how to keep their homes green. On-site seminars can be offered one or two times in the development phase and right before the new owners take occupancy. Once residents move to their new homes, it is recommended to send flyers via mail or email to remind them of the green features of their homes and inform them of how to use and maintain these features. Mailed or emailed flyers will work better than on-site seminars because many residents have full- or part-time jobs.

6) In addition, incentives should be considered for upgrading low-income housing to make it more energy-efficient and environmentally friendly. Currently there is a 500 dollar maximum tax credit for upgrading any housing features to make them energy-efficient. This maximum should be increased to keep up with the real cost of upgrading energy-consuming HVAC systems to energy-efficient ones. In particular, more aggressive incentives should be offered to households below a certain income level so that homeowners can be more active in upgrading their conventional houses to energy-efficient green ones.



## REFERENCE

- Alliance for Environmental Sustainability (2012), Retrieved May 22, 2012 from <http://www.alliancees.org/2011/11/16/leed-for-homes-outstanding-program-commitment-winner/>.
- Center for the Built Environment (2010). Occupant Indoor Environmental Quality (IEQ) Survey. Retrieved September 10<sup>th</sup>, 2010 from <http://www.cbe.berkeley.edu/research/survey.htm>.
- Habitat for Humanity (2009). Retrieved September 15<sup>th</sup>, 2010 from [http://www.habitat.org/newsroom/2009archive/08\\_04\\_2009\\_HFH\\_Home\\_Depot\\_Foundation.aspx](http://www.habitat.org/newsroom/2009archive/08_04_2009_HFH_Home_Depot_Foundation.aspx).
- Habitat for Humanity (2010). LEED for Homes grant. Retrieved September 15<sup>th</sup>, 2010 from <http://www.habitatmichigan.org/leed-homes-grant>.
- Habitat for Humanity of Kent County (2008). 2008 annual report: Rebuilding the American dream. Grand Rapids, MI: Habitat for Humanity of Kent County.
- Habitat for Humanity of Michigan (2011). Retrieved September 10<sup>th</sup>, 2011 from <http://habitatmichigan.org/habitat-michigan-affiliates-produced-223-homes-2011>.
- The White House (2010). Homestar Energy Efficiency Retrofit Program. Retrieved September 15<sup>th</sup>, 2010 from <http://www.whitehouse.gov/the-press-office/fact-sheet-homestar-energy-efficiency-retrofit-program>.
- Preiser, W. F. E. Rabinowitz, H. Z. & White, E. T. (1988). *Post Occupancy Evaluation*. New York: Van Nostrand Reinhold.
- U.S. Green Building Council (2010). LEED rating systems. Retrieved September 10<sup>th</sup>, 2010 from <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=222>.
- USGBC (2010). Retrieved August 31<sup>th</sup>, 2010 from <http://www.usgbc.org/ShowFile.aspx?DocumentID=2683>.

APPENDIX A INTERVIEW GUIDE FOR CASE STUDY WITH LEED-  
CERTIFIED HABITAT FOR HUMANITY HOMES IN MICHIGAN

**Exploring Economic, Environmental, and Residential Benefits of  
LEED-certified Habitat for Humanity in Michigan**

**Before Interview Date**

		Yes	No
Appointment confirmation	<ul style="list-style-type: none"> <li>• Call or email 2-3 days before the interview date</li> <li>• Let them know we want to see their LEED-certification when interviewing</li> <li>• Ask if they complete the survey</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>
Things to check	Camera	<input type="checkbox"/>	<input type="checkbox"/>
	Recording device (e.g., mp3, Ipod...)	<input type="checkbox"/>	<input type="checkbox"/>
	Laptop	<input type="checkbox"/>	<input type="checkbox"/>
	IEQ measuring kit & light meter	<input type="checkbox"/>	<input type="checkbox"/>
	Consent form	<input type="checkbox"/>	<input type="checkbox"/>
	Gift Card	<input type="checkbox"/>	<input type="checkbox"/>

**When Starting Interview**

Interview Date				
Interview Time	Starts at:	Ends at:		
Interviewer				
Interviewee (s)				
Location (Address)				
Consent Form signed?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
LEED certification checked?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>
Photos taken?	Exterior:	Yes	<input type="checkbox"/>	No <input type="checkbox"/>
	Interior:	Yes	<input type="checkbox"/>	No <input type="checkbox"/>
Recording device on?	Yes	<input type="checkbox"/>	No	<input type="checkbox"/>



## Interview Question

Question Category	Questions
Overall satisfaction	<ol style="list-style-type: none"> <li>1. How are you and your family satisfied with <i>your home</i>?</li> <li>2. How are you and your family satisfied with <i>your neighborhood environment</i>?</li> <li>3. What features in your home/neighborhood are you <i>most/least satisfied</i> with?</li> <li>4. How have your <i>living conditions</i> improved/changed since moving in to this home?</li> </ol>
Function & comfort	<ol style="list-style-type: none"> <li>1. Do you feel comfortable in your home environment? Physically? Emotionally?</li> <li>2. How does the (<i>temperature</i>) in your home enhance or interfere <b>your comfort</b>? <ul style="list-style-type: none"> <li>▪ <i>Temperature</i></li> <li>▪ <i>Humidity</i></li> <li>▪ <i>Electrical Lighting</i></li> <li>▪ <i>Day lighting</i></li> <li>▪ <i>Air quality</i></li> <li>▪ <i>Ventilation</i></li> <li>▪ <i>Acoustics- noise from outside/ noise within your home (noise from the next door, noise from mechanical systems..)</i></li> </ul> </li> </ol>
Interior space planning , Furnishings, and finishes	<ol style="list-style-type: none"> <li>1. How do you like the <i>interior space layout</i> of your home?</li> <li>2. Is <i>space layout</i> functional/efficient/productive? <ol style="list-style-type: none"> <li>a. <i>Room size</i></li> <li>b. <i>Furnishings</i></li> <li>c. <i>Finishes- colors, textures, aesthetical quality</i></li> </ol> </li> <li>3. Please describe any other issues related to the space layout, finishes, or furnishings.</li> </ol>
Building system performance	<ol style="list-style-type: none"> <li>1. How are your green home systems/technologies performing? <ul style="list-style-type: none"> <li>▪ <i>Overall performance</i></li> <li>▪ <i>HVAC system</i> <ul style="list-style-type: none"> <li>○ <i>Heating</i></li> <li>○ <i>Cooling</i></li> <li>○ <i>Ventilation</i></li> </ul> </li> <li>▪ <i>Lighting control</i></li> <li>▪ <i>Window operation</i></li> <li>▪ <i>Water efficiency</i></li> </ul> </li> <li>2. Please describe any other issues related to the building system performance</li> </ol>



<p>Energy efficiency</p>	<ol style="list-style-type: none"> <li>1. How are you satisfied with energy savings in your current home?</li> <li>2. Considering energy use, how efficiently is this home performing in your opinion? (compared to your previous home, is there big difference?) <ul style="list-style-type: none"> <li>▪ Electricity:</li> <li>▪ Natural gas:</li> <li>▪ Water:</li> </ul> </li> <li>3. What is your average temperature in your home? <p style="text-align: center;">Summer _____ F      Winter _____ F</p> </li> <li>4. Please tell me the average bill payment for: <ul style="list-style-type: none"> <li>▪ Water:        \$ _____ (summer) \$ _____ (winter)</li> <li>▪ Electricity: \$ _____ (summer) \$ _____ (winter)</li> <li>▪ Natural gas: \$ _____ (summer) \$ _____ (winter)</li> </ul> </li> <li>5. Please describe any other issues related to the energy efficiency in your home.</li> </ol>
<p>Perceived health impact</p>	<ol style="list-style-type: none"> <li>1. Is there anyone in your family members with <i>asthma, allergies, or any other health issues</i>?</li> <li>2. Have you experienced any changes (improvement) in your /your family's health conditions ever since you moved in to this home? <ul style="list-style-type: none"> <li>▪ Any changes in asthma symptoms, respiratory allergies, depression, stress level</li> <li>▪ Any changes in absenteeism, sick days of you and your kids</li> <li>▪ Any improvement in your children's school performance (ex: better grade? Study harder? Focus better?)</li> </ul> </li> <li>3, Please describe any other issues related to your family's health in your home.</li> </ol>
<p>Attitude and behavior</p>	<ol style="list-style-type: none"> <li>1. Have you experienced any changes in <i>your life style</i> ever since you moved in to your current home?</li> <li>2. Have your experienced any changes in the <i>relationships between members</i> of our household</li> <li>3. Environmental changes: <ul style="list-style-type: none"> <li>○ Any changes in your (or your family members') <i>environmental attitude</i>? – your interests in environmental issues/concerns about the preserving environments for the future generation</li> <li>○ Any changes in your (or your family members') <i>environmental behaviors</i>? (e.g., recycling, energy saving – turning off light/tv/computer..., purchasing eco-friendly product....)</li> </ul> </li> </ol>

<p>Construction process</p>	<ol style="list-style-type: none"> <li>1. Did you get involved in the planning, design, and construction of your home? :space layout, room size, finishing materials...</li> <li>2. If so, how was it? What are the benefits of participating in those processes?</li> <li>3. How was the LEED certification process? Informed well about LEED? (any education/training session?) Understanding/ acceptance about higher initial cost</li> <li>4. How do you feel about LEED-certified home? (proud?) <ol style="list-style-type: none"> <li>a. Did (Will) you recommend LEED-certified home to other people?</li> <li>b. If you need to move, do you prefer to moving to LEED-certified home?</li> </ol> </li> </ol>
<p>General comments</p>	<ol style="list-style-type: none"> <li>1. Do you have any additional comments or recommendations to improve designs and performances of LEED certified green home building?</li> </ol>

APPENDIX B QUESTIONNAIRE FOR MAIL SURVEY WITH LEED-  
CERTIFIED HOMES IN THE MIDWEST



**How Do You Like Your LEED-Certified Home?**

Before you begin, please make sure that you have read the letter that accompanied this survey. The letter contains important information about your participation in this research project. If you did not receive the letter please contact project manager Jill Hardy by phone: (517) 353-1765 or email: [jill.hardy@ssc.msu.edu](mailto:jill.hardy@ssc.msu.edu).

**I. This section asks about your LEED certified home in general.**

1. Which one of the following best describes your present home? *(Please check one)*
  - <sup>1</sup> Single-family detached house      <sup>3</sup> Condominium, duplex, or townhome (multi-family attached)
  - <sup>2</sup> Apartment building      <sup>4</sup> Other *(please specify)* \_\_\_\_\_
2. Do you own or rent the home in which you now live? *(Please check one)*
  - <sup>1</sup> Own home      <sup>2</sup> Rent home      <sup>3</sup> Other *(please specify)* \_\_\_\_\_
3. What LEED rating did your home obtain?
  - <sup>1</sup> Platinum    <sup>2</sup> Gold    <sup>3</sup> Silver    <sup>4</sup> Certified    <sup>5</sup> Not sure
4. In approximately what year was your home built? \_\_\_\_\_ year of construction
5. How long have you lived in your home? \_\_\_\_\_ years and \_\_\_\_\_ months
6. What is the approximate square footage of your home? Approximately \_\_\_\_\_ sq. ft.
7. Not including basements, how many levels is your home? \_\_\_\_\_ levels
8. Does your home have a finished basement?
  - <sup>1</sup> Yes    <sup>2</sup> No, unfinished    <sup>3</sup> No, my home has no basement
9. How many bedrooms do you have in your home? \_\_\_\_\_ bedrooms
10. Is your LEED certified home built by Habitat for Humanity?    <sup>1</sup> Yes    <sup>2</sup> No
11. Including sleeping, how many hours do you typically spend at your home each day? \_\_\_\_\_ hours
12. a. How many adults, 18 years of age or older, currently live in your home? \_\_\_\_\_ adults
  - b. How many children under the age of 18 currently live in your home? \_\_\_\_\_ children

**II. This section asks about your overall satisfaction with your home environment.**

1. Please rate your level of dissatisfaction or satisfaction for each of the following items.

	<i>Very Dissatisfied</i>						<i>Very Satisfied</i>
	1	2	3	4	5	6	7
a. In general, how satisfied or dissatisfied are you with your current LEED certified home?	1	2	3	4	5	6	7
b. In general, how satisfied or dissatisfied are you with your current neighborhood?	1	2	3	4	5	6	7

**2. Listed below are some aspects of your home's indoor environment. Please rate your level of dissatisfaction or satisfaction with each aspect of your LEED certified home.**

How satisfied or dissatisfied are you with...	<i>Very Dissatisfied</i>						<i>Very Satisfied</i>
	1	2	3	4	5	6	7
a. The space layout overall	1	2	3	4	5	6	7
b. The size of space available for daily activities	1	2	3	4	5	6	7
c. Your home furnishings and furniture	1	2	3	4	5	6	7
d. The colors and materials of interior finishes	1	2	3	4	5	6	7
e. The visual privacy from neighbors	1	2	3	4	5	6	7
f. Outside views	1	2	3	4	5	6	7
g. The temperature in your home	1	2	3	4	5	6	7
h. The humidity in your home	1	2	3	4	5	6	7
i. The air quality in your home	1	2	3	4	5	6	7
j. The amount of daylight in your home	1	2	3	4	5	6	7
k. The quality and visual comfort of artificial light in your home	1	2	3	4	5	6	7
l. The acoustic quality in your home	1	2	3	4	5	6	7
m. General cleanliness of your neighborhood	1	2	3	4	5	6	7

**3. Please rate the importance of each aspect of your home's indoor environment to your overall residential comfort and satisfaction.**

How important is...	<i>Very Unimportant</i>						<i>Very Important</i>
	1	2	3	4	5	6	7
a. The space layout overall	1	2	3	4	5	6	7
b. The size of space available for daily activities	1	2	3	4	5	6	7
c. Your home furnishings and furniture	1	2	3	4	5	6	7
d. The colors and materials of interior finishes	1	2	3	4	5	6	7
e. The visual privacy from neighbors	1	2	3	4	5	6	7
f. Outside views	1	2	3	4	5	6	7
g. The temperature in your home	1	2	3	4	5	6	7
h. The humidity in your home	1	2	3	4	5	6	7
i. The air quality in your home	1	2	3	4	5	6	7
j. The amount of daylight in your home	1	2	3	4	5	6	7
k. The quality and visual comfort of artificial light in your home	1	2	3	4	5	6	7
l. The acoustic quality in your home	1	2	3	4	5	6	7
m. General cleanliness of your neighborhood	1	2	3	4	5	6	7

**4. Please rate the following aspects of your quality of life in your LEED certified home.**

	<i>Poor</i>						<i>Excellent</i>
	1	2	3	4	5	6	7
a. Overall, my physical well-being is...	1	2	3	4	5	6	7
b. Overall, my mental/emotional state is...	1	2	3	4	5	6	7
c. Overall, my ability to handle stress is...	1	2	3	4	5	6	7
d. Overall my enjoyment of life is...	1	2	3	4	5	6	7
e. Overall, my quality of life is...	1	2	3	4	5	6	7

**5. Please indicate your level of disagreement or agreement with the following statements.**

<i>Since becoming a resident of a LEED certified home...</i>	<i>Strongly Disagree</i>							<i>Strongly Agree</i>	<i>Does not apply</i>
My living conditions have improved.	1	2	3	4	5	6	7		
My child(ren)'s school performance has improved.	1	2	3	4	5	6	7	NA <sup>8</sup>	
The health of members in my household has improved.	1	2	3	4	5	6	7		
I have become more engaged with my neighbors.	1	2	3	4	5	6	7	NA <sup>8</sup>	
Overall, my quality of life has been improved.	1	2	3	4	5	6	7		

**6. Please rate the following aspects of the indoor environment of your LEED certified home by circling the appropriate number between each pair of opposite descriptors.**

Air quality	Stale	1	2	3	4	5	6	7	Fresh
Air smell	Pleasant	1	2	3	4	5	6	7	Unpleasant
Air movement	Still	1	2	3	4	5	6	7	Circulating
Humidity	Humid	1	2	3	4	5	6	7	Dry
Temperature (summer)	Hot	1	2	3	4	5	6	7	Cold
Temperature (winter)	Cold	1	2	3	4	5	6	7	Hot
Lighting quality	Comfortable	1	2	3	4	5	6	7	Uncomfortable
Acoustic quality	Noisy	1	2	3	4	5	6	7	Quiet

**7. Please indicate how you feel about your LEED certified home on each of the following dimensions by circling the appropriate number between the pair of opposite descriptors.**

Uncomfortable	1	2	3	4	5	6	7	Comfortable
Unattractive	1	2	3	4	5	6	7	Attractive
Unsafe	1	2	3	4	5	6	7	Safe
Unpleasant	1	2	3	4	5	6	7	Pleasant
Inconvenient	1	2	3	4	5	6	7	Convenient
Not Stimulating	1	2	3	4	5	6	7	Stimulating
Unsanitary	1	2	3	4	5	6	7	Sanitary
Unhealthy	1	2	3	4	5	6	7	Healthy
Unsustainable	1	2	3	4	5	6	7	Sustainable

**III. This section asks about you and your family's overall well-being in your home.**

**1. a. Of the people who live in your LEEDS certified home, how many currently smoke cigarettes or cigars? \_\_\_\_\_ people**



*If no people who live in your home smoke, go to part III question 2.*

**b. Which one of the following statements best describes the rules about smoking inside your home?**

- <sup>1</sup> No one is allowed to smoke anywhere inside my house
- <sup>2</sup> Smoking is allowed in some rooms or at some times
- <sup>3</sup> Smoking is permitted anywhere inside my home

c. How many cigarettes or cigars do you and/or the other people living in your home typically smoke each day?

1-5 \_\_\_\_\_ 6-10 \_\_\_\_\_ 11-15 \_\_\_\_\_ 15-20 \_\_\_\_\_ more than 20 \_\_\_\_\_

2. How many dog(s) and/or cat(s) do you own that spend time inside your LEED certified home?


Number of Dog (s) \_\_\_\_\_ Number of Cat (s) \_\_\_\_\_

3. Listed below are some common emotional issues. Please indicate for how many adults and children living in your LEED certified home each is a problem. Then, answer the questions regarding the person, if any, living in your home for whom the emotional issue is the biggest problem. (If no one living in the house has a particular emotional issue, please enter '0' for that issue. If you do not have any children living in your home, please leave the number of children with this emotional issue blank.)

Problem	Number of people living in your home with this emotional issue		Thinking about the person living in your LEED certified home for whom this issue is the biggest problem:	
	# children (under 18 years old)	# adults (18 years and up)	In the past <u>four</u> weeks, how many days did this issue interfere with this household member's normal activities?	Do you think the number of days this problem interferes with the household members normal activities has increased, decreased or stayed about the same since you moved into your LEED home?
Anxiety				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Depression				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Stress				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Lack of confidence				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Lack of motivation				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Low energy level				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Other (specify: _____)				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same

4. Listed below are some common health issues. Please indicate for how many adults and children in your household each is a problem and answer the questions regarding the person in your household for whom the health issue is the biggest problem. (If no one living in the house has a particular health issue, please enter '0' for that issue. If you do not have any children living in your home, please leave the number of children with this health issue blank.)

Problem	Number of people living in your home with this health issue		Thinking about the person living in your LEED certified home for whom this issue is the biggest problem:	
	# children (under 18 years old)	# adults (18 years and up)	In the past <u>four</u> weeks, how many days did this issue interfere with this household member's normal activities?	Do you think the number of days this issue interferes with this household member's normal activities has increased, decreased or stayed about the same since you moved in to your LEED home?
Asthma				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Respiratory allergies				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Sensitivities to chemicals				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Other breathing difficulty (specify : _____)				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Hypertension				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Cardiovascular diseases				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Irritation- eyes/ nose/ throat/ skin				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Headache/ Fatigue/ Dizziness				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Visual discomfort/ Eye strain				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
General physical discomfort				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same
Other Health Issue (specify: _____)				<input type="checkbox"/> Increased <input type="checkbox"/> Decreased <input type="checkbox"/> Stayed about the same

 The next two questions are about *asthma, respiratory allergies, or sensitivity to chemicals*.  
 If *no one* living in your LEED certified home has issues with *asthma, respiratory allergies, or sensitivity to chemicals*, please go to section IV question 1.





**8. For each of the building features listed below, please indicate how dissatisfied or satisfied you are with the performances and effectiveness of that feature.**

	<i>Very Dissatisfied</i>				<i>Very Satisfied</i>			<i>Does not apply</i>
	1	2	3	4	5	6	7	NA <sup>8</sup>
Heating system	1	2	3	4	5	6	7	NA <sup>8</sup>
Cooling system	1	2	3	4	5	6	7	NA <sup>8</sup>
Hot water supply	1	2	3	4	5	6	7	NA <sup>8</sup>
Electrical Lighting	1	2	3	4	5	6	7	NA <sup>8</sup>
Insulation	1	2	3	4	5	6	7	NA <sup>8</sup>
Ventilation	1	2	3	4	5	6	7	NA <sup>8</sup>
Air tightness	1	2	3	4	5	6	7	NA <sup>8</sup>
Appliances	1	2	3	4	5	6	7	NA <sup>8</sup>
Thermostats	1	2	3	4	5	6	7	NA <sup>8</sup>
Windows & doors	1	2	3	4	5	6	7	NA <sup>8</sup>
Window treatment	1	2	3	4	5	6	7	NA <sup>8</sup>
Toilets	1	2	3	4	5	6	7	NA <sup>8</sup>
Faucets	1	2	3	4	5	6	7	NA <sup>8</sup>
Showerheads	1	2	3	4	5	6	7	NA <sup>8</sup>
Solar energy system	1	2	3	4	5	6	7	NA <sup>8</sup>
Wind power	1	2	3	4	5	6	7	NA <sup>8</sup>
Water conservation systems	1	2	3	4	5	6	7	NA <sup>8</sup>

**9. How well informed do you feel about using the features in your home mentioned above in part IV question 8? (Part IV question 8 is the question immediately before this question.)**

Not well informed at all	1	2	3	4	5	6	7	Extremely well informed
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**10. Please indicate how dissatisfied or satisfied you are with the efficiency of the following in your LEED certified home?**

	<i>Very Dissatisfied</i>				<i>Very Satisfied</i>		
	1	2	3	4	5	6	7
Water usage	1	2	3	4	5	6	7
Electricity usage	1	2	3	4	5	6	7
Natural gas , propane or other heating fuel usage	1	2	3	4	5	6	7

**V. This section asks about household activities and habits.**

1. Have you or a family member attended any LEED classes for homeowners? <sup>1</sup> Yes <sup>2</sup> No
2. Are you a member of any group whose main aim is to preserve or protect the environment?  
<sup>1</sup> Yes <sup>2</sup> No

**3. Given an opportunity, how likely would you be to make a special effort to do the following?**

	<i>Not likely at all</i>	<i>Somewhat likely</i>	<i>Moderately likely</i>	<i>Very likely</i>	<i>Extremely likely</i>
Consider using Energy Star appliances at home	1	2	3	4	5
Consider buying LEED/ Green home for your next house	1	2	3	4	5
Use products made from recycled materials	1	2	3	4	5
Use household chemicals such as cleaning solutions that are environmentally friendly	1	2	3	4	5
Buy organic fruits and vegetables	1	2	3	4	5
Avoid buying products from a company that you know may be harming the environment	1	2	3	4	5

**VI. This section asks about you .**

**1. In what year were you born?** \_\_\_\_\_

**2. What is your gender?** <sup>1</sup> Male <sup>2</sup> Female

**3. What is your race? (Check all that apply)**

- <sup>1</sup> White <sup>4</sup> Black or African-American <sup>5</sup> Asian  
<sup>2</sup> Native Hawaiian or other Pacific Islander <sup>6</sup> American Indian or Alaska Native  
<sup>3</sup> Other (please specify) \_\_\_\_\_

**4. Are you...**

- <sup>1</sup> Married <sup>3</sup> Divorced <sup>5</sup> Widowed <sup>6</sup> Separated  
<sup>2</sup> Never married <sup>4</sup> Member of an unmarried couple

**5. Are you presently... (Check only one)**

- <sup>1</sup> Employed full or part-time <sup>4</sup> Self-employed <sup>7</sup> Unemployed  
<sup>2</sup> A homemaker <sup>5</sup> A student <sup>8</sup> Retired  
<sup>3</sup> Unable to work <sup>6</sup> Other (please specify) \_\_\_\_\_

**6. What is the highest level of education you have completed?**

- <sup>1</sup> No formal education <sup>4</sup> Completed high school or GED <sup>6</sup> 4-year college degree  
<sup>2</sup> Completed grade school <sup>5</sup> Some college or technical school  
<sup>7</sup> Graduate or professional degree <sup>3</sup> Some high school

**7. What was your approximate household income before taxes from all sources, in 2011?**

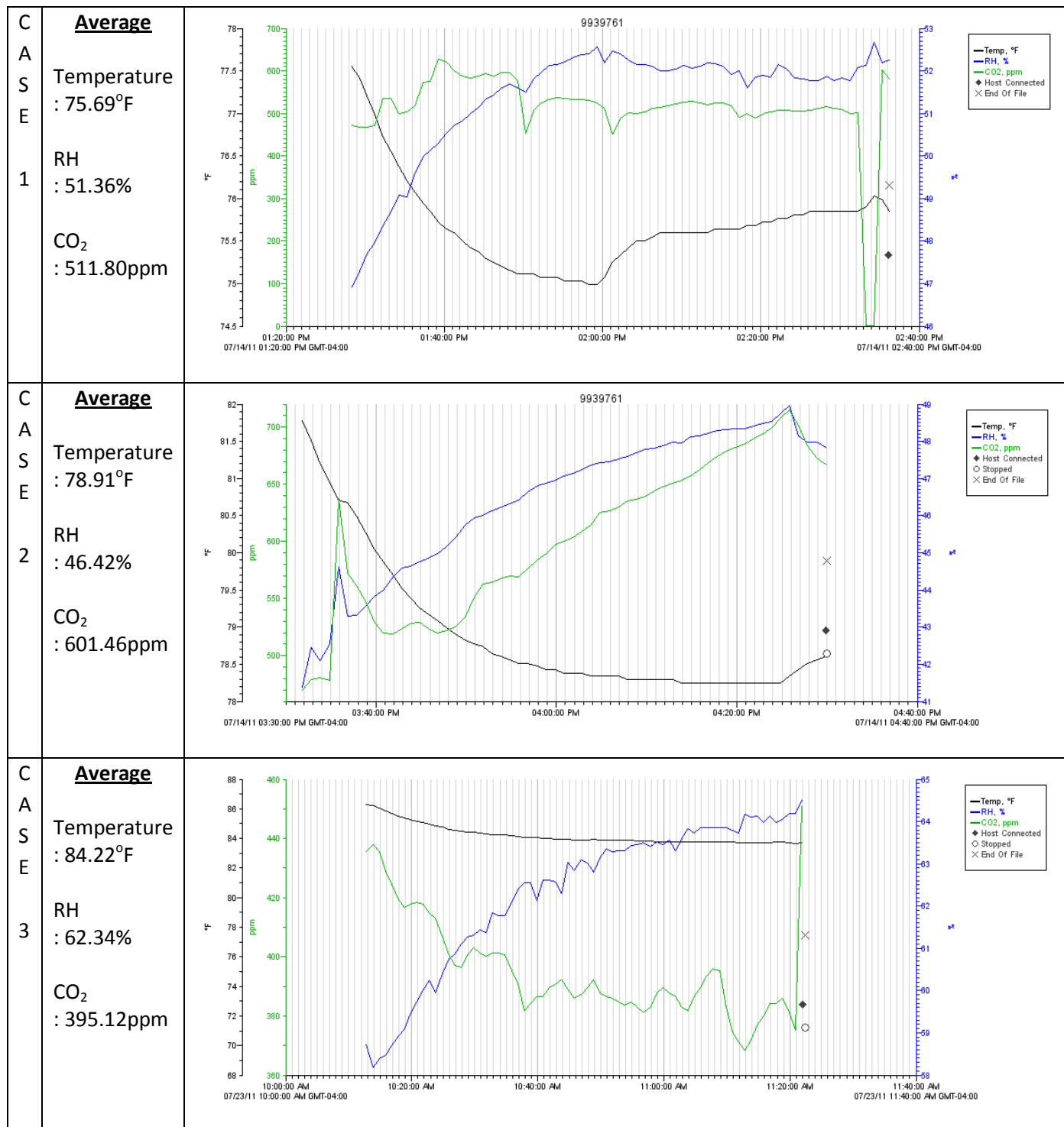
- <sup>1</sup> Less than \$20,000 <sup>3</sup> \$40,000 to \$59,999 <sup>5</sup> \$80,000 to \$99,999  
<sup>2</sup> \$20,000 to \$39,999 <sup>4</sup> \$60,000 to 79,999 <sup>6</sup> \$100,000 and over

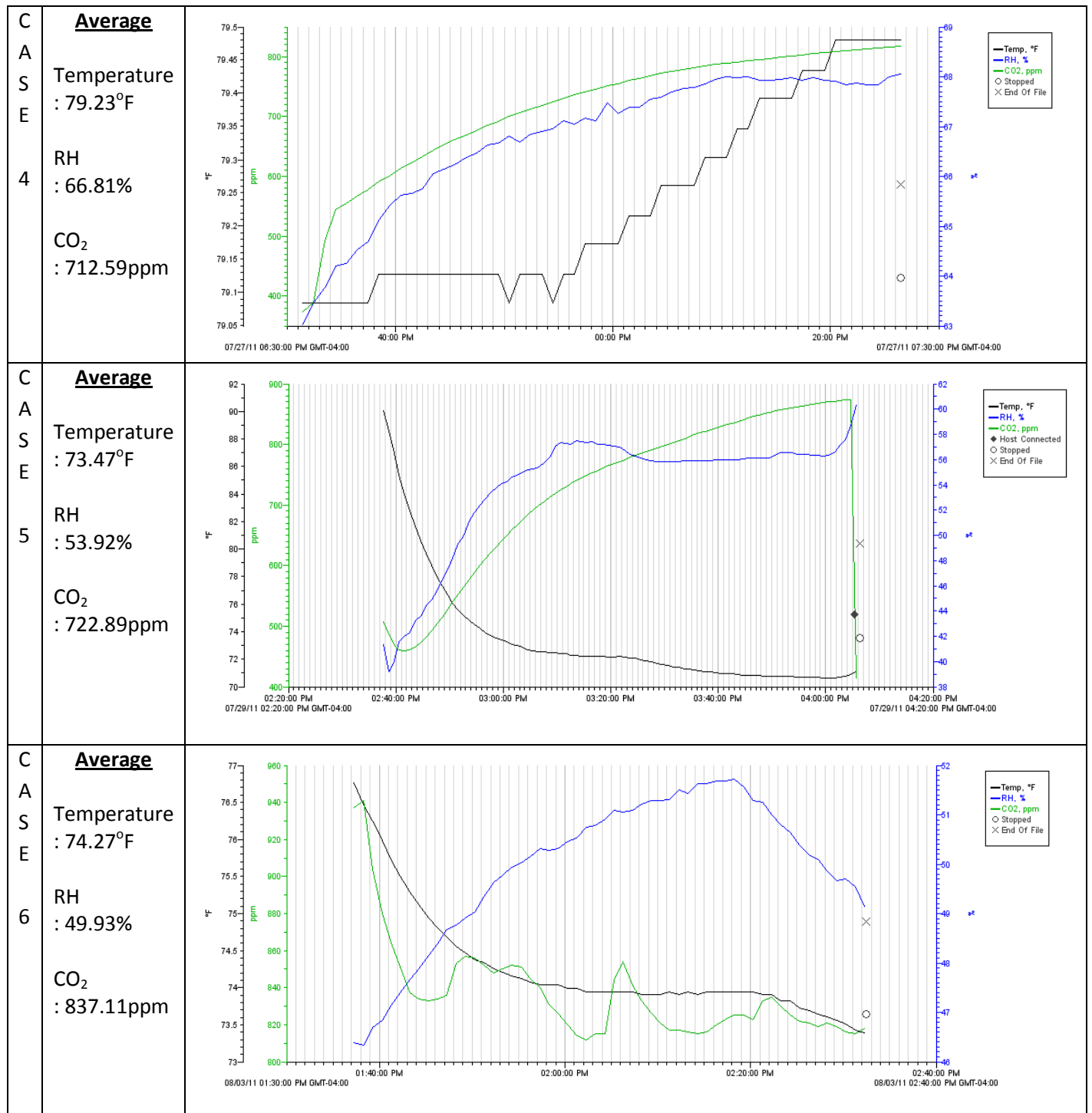
**8. What is your five-digit zip code?** \_\_\_\_\_

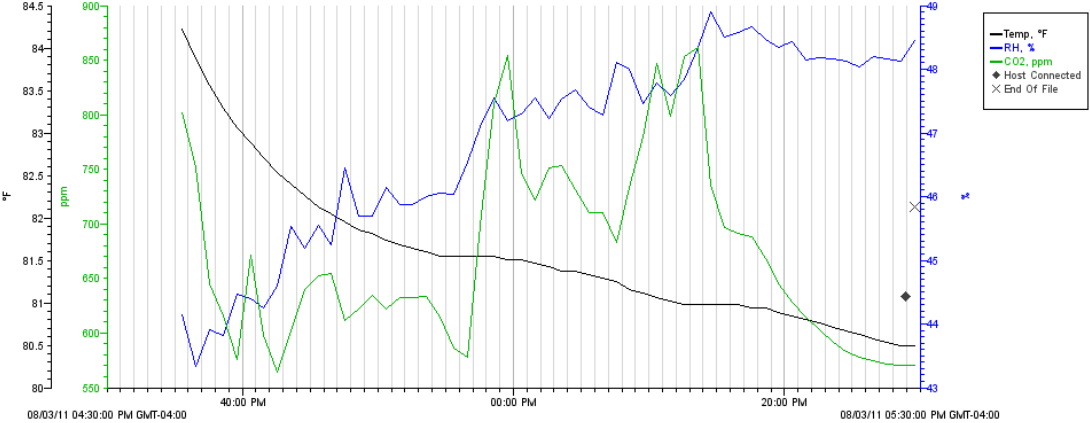
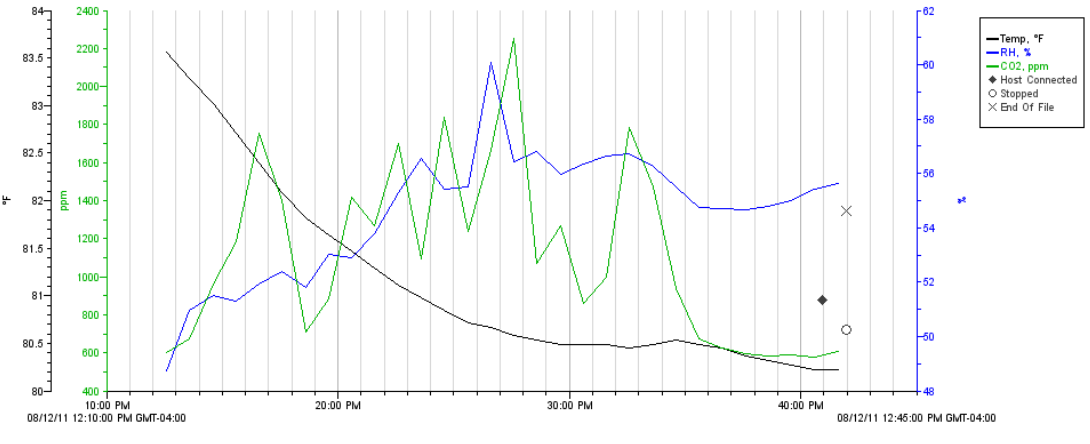
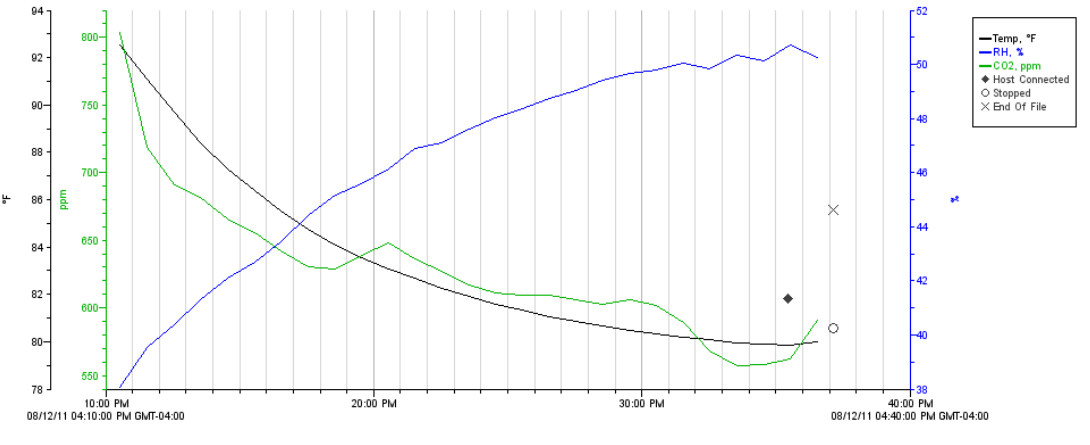
**9. Please use this space for any additional comments you would like to make about your LEED certified home or this questionnaire.**

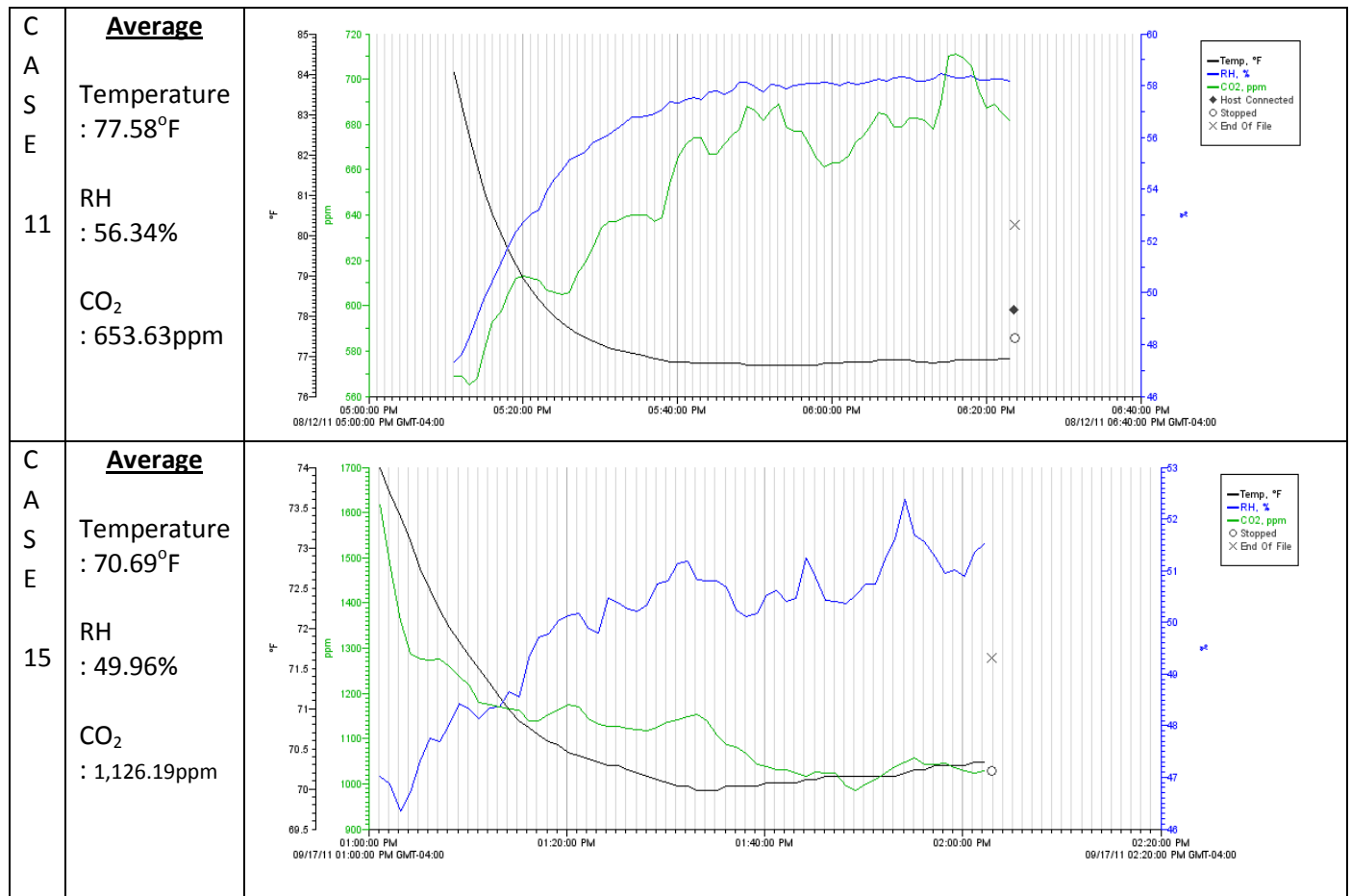
**THANK YOU FOR YOUR TIME AND EFFORT IN COMPLETING THIS SURVEY!  
PLEASE REMEMBER TO RETURN THE GREEN SLIP TO RECEIVE YOUR GIFT CARD.**

## APPENDIX C MONITORING OF TEMPERATURE, RELATIVE HUMIDITY, AND CO<sub>2</sub>





C A S E  7	<p><b>Average</b></p> <p>Temperature : 81.56°F</p> <p>RH : 46.86%</p> <p>CO<sub>2</sub> : 672.62ppm</p>	
C A S E  9	<p><b>Average</b></p> <p>Temperature : 81.13°F</p> <p>RH : 54.56%</p> <p>CO<sub>2</sub> : 1,109.27ppm</p>	
C A S E  10	<p><b>Average</b></p> <p>Temperature : 83.31°F</p> <p>RH : 46.47%</p> <p>CO<sub>2</sub> : 628.04ppm</p>	



Note: Data for Case 8, 12, 13, and 14 are not available.