Informing the Debate

Economic Benefits and Environmental Sustainability

Low-income Green Home Development in Michigan

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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 c ertification 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
Total	**2,889**	**5,000**	**7,567**	**19,357**

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 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 under-utilized 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 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 Post-Occupancy Evaluation 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.

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 perceive 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:** 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.

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