

“Barriers to Net Zero Housing in the US”

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A Passive House is a house that creates nearly as much energy as it consumes. Though very popular in Europe, Passive House movement in the United States has been hampered by the cost, availability of passive construction materials, in addition to the lack of skilled labor. However, this is currently changing by the cost drop of Passive Houses, which is only 5% to 10% higher than the cost of conventional houses. The objective of this study was to identify the major barriers to large-scale adoption of Passive Housing concept in the United States. Data was collected for this study through personal interviews and survey questionnaire with home builders in the Atlanta area. The prime beneficiaries of this study were home-builders who are pro passive housing but are currently hindered by the system. The study provided recommendations on benefits of Passive House concept, thereby incentivizing the home builders to challenge the existing barriers to Passive House. Results from the study showed homebuilders' preference for EarthCraft House rather than Passive House due to their less strict standards, and feasibility.

Key words: *Passive House, home-builders, barriers, cost, EarthCraft house.*

Introduction

Energy efficiency is a vast topic, compromising broad types of disciplines (Shafer, 2003). It has proved to be a cost-effective strategy for building economies with a noticeable reduction in energy consumption. Today, Energy efficiency in construction is gaining a lot of ground in the U.S, thanks to the Department of Housing and Urban Development (HUD) efforts of introducing strategies for saving energy consumption in the Public housing (Shafer, 2003). On the other hand, Passive Housing is becoming the world's leading standard in energy efficient design. It first started out as a construction concept for residential buildings in Central Europe, then the concept was applied to other types of buildings. Passive House is very famous in Europe, but is still obscure to homebuilders, architects, developers, engineers in the United State (Ruegemer, 2010). Consequently, a lot of questions are raising about the Passive House in the United State.

Currently, there are multiple programs for new home construction and renovation that provide a framework for certifying a home's greenness. EarthCraft, LEED for Homes, and Passive House are three of the most well-known home certification programs. They range in level of complexity and vary in the target for efficiency.

The Passivhaus standard originated by a discussion between Bo Adamson of Lund University, Sweden, and Wolfgang Feist of the Institute for Housing and the Environment, Germany in the late 1980's. Their idea was explored through numerous research projects (Stecher, 2008). Today, not only housing but also Energy-efficient buildings are gaining popularity around the world and in the United States with considerable energy consumption cut compared to traditional buildings (Walliser et al., 2012).

The objective of this study was to identify the major obstacles and barriers to large-scale adoption of Passive House construction in the United States by homebuilders. As a new construction method this paper intended to clarify the practice of passive house and the benefits it provides, including Energy efficiency and cost-effectiveness (J. Mathias & D. Mathias, 2009). The study was to incentive and inspire homebuilders toward the adoption of Passive Housing, contributing in a market shift towards sustainability and energy savings (Koebel, 2008).

A collaboration between literature review and personnel investigations were explored in order to add rigor to previous research. The study underlined a new construction method analysis for a better understanding of the Passive House concept by homebuilders in the United States.

The main beneficiaries of this study were home-builders who are pro Passive Housing but are currently hindered by the system. The comprehension of the broad benefits it provides to the user as far as its energy efficiency, environment comfort, and air quality are extremely important. According to McGarry, (2013), “This type of construction seems not only to make economic and environmental sense, but enhances our quality of life, too” (p. 199). In addition to the sensible investment it provides (Brach, 2012). This paper attempted to extend the construction body of knowledge by investigating the Passive House concept and feasibility in the United States.

Passive House’ Principles

Passive House requires standards in order to meet the certification criteria. Passive house measures are: airtightness, orientation, massing, insulation, heat recovery, passive use of solar energy, solar shading, elimination of thermal bridges, and incidental internal heat sources. “In order to design and realize a high-quality passive house project, it is necessary to take care of its efficiency from the brief stage to the end of its life's service” (KAKLAUSKAS, RUTĖ, GUDAUSKAS, & BANAITIS, 2011).

A Passive House understands a set of design fundamentals used to attain a measurable and extreme levels of energy efficiency within a specific perceptible comfort level (J. Dinkle, personal communication, April 24, 2015). According to PHIUS (2015) “Maximize your gains, minimize your losses” summarize the approach. The Passive House must satisfy very rigorous requirements regarding both their design and construction. The Six building-science principles that apply for Passive buildings are described below as reported by (PHIUS, 2015):

- It employs continuous insulation through its entire envelope without any thermal bridging.
- The building envelope is extremely airtight, preventing infiltration of outside air and loss of conditioned air.
- It employs high-performance windows and doors (typically triple-paned).
- It uses some form of balanced heat- and moisture-recovery ventilation and uses a minimal space conditioning system.
- It manages solar gain to exploit the sun's energy for heating purposes and to minimize it in cooling seasons.

Passive building principles can be applied to all building typologies--from single-family homes to apartment building to offices and skyscrapers.” (PHIUS, 2015). McGarry (2013), an economics lecturer who built a family house based on passive housing criteria in the Pyrenees in the year of 2013. He claimed that after six months in use: The Passive House demonstrated two major rendering. The house was very economical to run, and the level of comfort as far as temperatures was very balanced throughout the house and almost effortless. Passive design strategies carefully model and balance a complete set of characteristics including heat emissions from appliances and occupants. As a result, it maintains the building at comfortable and consistent indoor temperatures throughout the heating and cooling seasons. Thus, passive buildings offer tremendous long -term benefits in addition to energy efficiency (J. Dinkle, personal communication, April, 2015):

- Superinsulation and airtight construction provides unmatched comfort and even in extreme conditions.
- Continuous mechanical ventilation of fresh filtered air assures superb air quality.
- Comprehensive systems approach to modeling, design and construction produce extremely resilient buildings.
- Passive Housing is the best path to Net Zero and Net Positive buildings because it minimizes the load that renewables are required to provide (PHIUS, 2015).

Research Methodology

The adopted research approach in this paper was the triangulated studies which involved both qualitative and quantitative approaches for a multi-dimensional view of the subject. The primary data used in this paper was collected through personal interviews, and a survey questionnaire addressed to homebuilders in Atlanta, GA. The interviews were carried out during March and April, 2015, according to their authority to influence decision-making related to the realization of Passive houses. The actors' selection was made based on the intended audience addressed on the paper. The Greater Atlanta Home Builders Association (D. Ellis, personal communication, March 10, 2015), the National Passive House Alliance (J. Dinkle, personal communication, April 24, 2015), Airedale Energy Consultants (B. Kitchell, personal communication, April 2, 2015), Earth craft homebuilders, and South face Energy Institute. 6 personal interviews, and 69 electronic survey questionnaire were conducted in order to collect data for the study. The secondary data was based on factual data and literature search from previous research with different boundary conditions. . The statistical tests used in this paper are the inferential statistics which are the set of statistical tests we used to make inferences about the collected data. These statistical tests allowed us to make inferences because they can tell us if the pattern we are observing is real or just due to chance. Six questions were driven from the analysis of the literature review and personnel investigation:

- 1-What are the motive forces for making the Passive House's concept conventional?
- 2-What obstacles to adoption are kept by homebuilders?
- 3-Why Passive House is still considered an innovation?
- 4-Do you consider the following criteria for Passive House construction? If so, at what level?
- 5-Do you think Passive Houses can be replaceable by EarthCraft Houses? If so, Why?
- 6-If you have to choose between Passive House and EarthCraft House construction, what will you adopt?

Background

The study point of departure was interest and curiosity for the passive house concept practices in the United States. First, since Passive House was born in Germany, numerous literature covered the subject mainly in Europe. Counter to the literature that was written in the United States. In addition, most of the papers favors the consumer as the main actor and prime intended audience neglecting the homebuilders. Thus, broad questions were framed from the literature review due to the lack of research in this topic (Berker & Bharathi, 2012). This paper attempted to add rigor to the existing research by addressing the homebuilder's challenges to adopt Passive Housing as a major actor exclusively in the United States where this concept is still considered an innovation rather than a mainstream.

Energy Efficiency

Providing dramatic energy reduction, up to 90% for heating and cooling demand from average existing in conventional houses (J. Mathias & D. Mathias, 2009). The Passive House provides an automatic perfect air quality with negligible technical effort, and minimal heating recovery (McGarry, 2013). Moreover, the Passive House combines a high-level comfort with very low energy consumption, and extreme low heating costs, even with energy cost's encasement. It also contributes to environment's protection and preserves natural resources as gas and oil.

Cost and affordability

Added construction costs for high performance are substantially offset by a reduction in systems sizing (J. Mathias & D. Mathias, 2009). Because the reduced energy use translates into lower bills and protection from future energy shocks, occupancy is affordable (McGarry, 2013). However, several additional costs were mentioned such as the relationship between gross floor area and living floor area, resulting in additional production costs and additional investment costs.

Passive house components

The Passive House components such as thermal windows (triple panels), glazing, heat-recovery ventilation, air changers, split units of conditioning energy recovery ventilator (CERV) , and insulation are vital elements to meet the standards and achieve the criteria (J. Dinkle, personal communication, April 24, 2015).

Time & Labor

Time can be gained and by experience and repetitive practice of the passive house concept (Ruegamer, 2010). Labor was evaluated by experience in similar project (Hens, 2012). Inexperienced labor can result in serious building mistakes and failure to achieve and pass the Passive House certification and all that at the cost of the quality and time of the project.

Comfort

The Passive House provides a unique combination of fresh, high-quality indoor air. A free of mold and dangerous levels of typical indoor air contaminants (Brach, 2012). In addition to a quiet interior environment with steady temperatures and no drafts (Mlecnik, 2013). McGarry (2013)” This type of construction seems not only to make economic and environmental sense, but to enhance our quality of life, too.”

Climate

According to the Passive House Institute US, achievement of Passive House was a challenge. They confirmed that a single standard for all North American climate zones is unworkable. “In some climates, meeting the standard is cost prohibitive, in other milder zones it's possible to hit the European standard while leaving substantial cost-effective energy savings unrealized.” (J. Dinkle, personal communication, April 24, 2015).

Results & Inferences

Interview study

In this section the results from the interviews and survey questionnaire are summarized and presented with quotations to highlight the findings:

The general perspective to Passive House concept from Homebuilders

Conducted interviews demonstrated homebuilders’ perception of Passive House as a great way to decrease energy consumption. Moreover, Passive House provides a practical option for cost-efficient house that offers a high comfort level while using very little energy for cooling and heating. For some other homebuilders, Passive House concept was obscure and they were not really familiar with it functionality. They were also reluctant to passive house cost which is higher than a conventional house whereas the demand is not really there to pay for it as the moment.

Motive forces for making the Passive House’s concept conventional

First, energy costs higher than they are currently. Most homebuilders affirm that Passive House is not gaining as much ground in the United States as it is the case in Europe due to the energy prices which are still fair to consumers. If energy prices go up, Passive Housing will see an urgent demand and will become a mainstream after few years. Second, individual desire to use less energy will help the market shift towards the Passive House while benefiting from a better indoor air quality and comfort. In addition to marketing and ease of achieving program standards, which will encourage and give homebuilders a sort of guaranty to engage in Passive Housing.

Obstacles to adoption kept by homebuilders

Perceived additional cost and expenses to achieve the criteria makes Passive House's cost prohibitive for most homebuilders. Additionally, materials' pricing, and level of skilled labor. The consumers' demand for Passive House is also very limited for the time being, due to their unfamiliarity with the benefits it provides. Moreover, Passive House marketing was expressed as a big concern by homebuilders. Finally, the lack of education and certified professionals to design and achieve Passive Houses according to standards.

Why Passive House is still considered an innovation?

For most homebuilders being less familiar and unaware of the concept in practice and market of the Passive House which is not being used very much by the industry. In counter to professionals from the Passive House Alliance US who see Passive House as a mainstream rather than an innovation, and affirm that it will be in the near future before anybody realize it.

Homebuilders' choice between Passive House and EarthCraft House

The majority of homebuilders' showed an apparent preference for EarthCraft house rather than Passive House, because Earthcraft currently employs a system that people can identify with both buyers and builders. Another reason, is that EarthCraft House is more marketable in the actual time. On the other hand, professionals from The Passive House Alliance see a major difference between the two concepts and judge that the Passive House concept is more energy-efficient and cannot be replaceable by EarthCraft House.

Data analysis and observations driven from interviews and survey questionnaire was translated in form of the following tables and charts.

Table 1: Data was evaluated based on averages and common trades. A criteria system was used for Passive House analyses based on relevant literature and experts' methods (KAKLAUSKAS et al., 2011).

Table 1

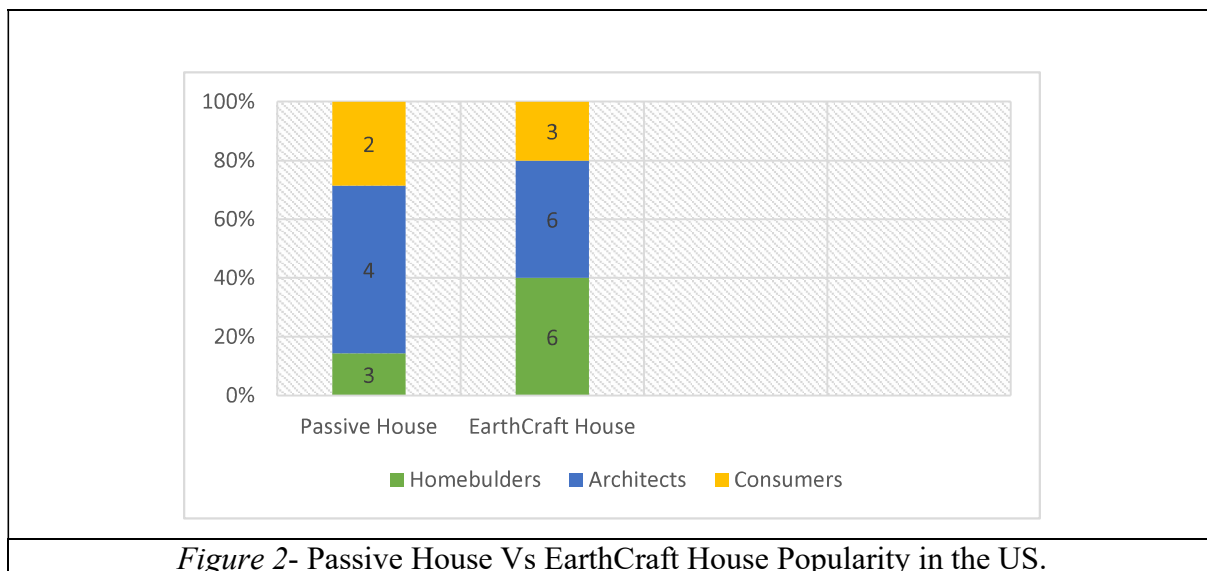
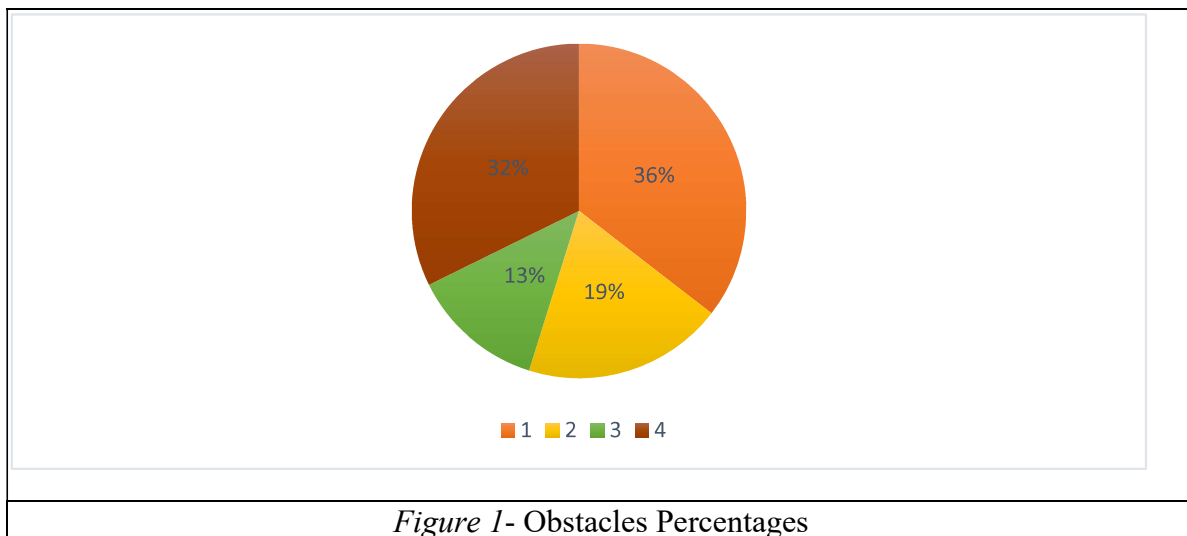
Passive House Criteria

Criteria	Yes	No	Not at all Important	Slightly Important	Important	Fairly Important	Very Important
Orientation	95%	5%					X
Special Insulation	100%						X
Solar Energy Panels	65%	25%		X			
Solar Shading	90%	10%				X	
Airtight Envelope	100%	0					X
Special Components (doors, windows)	95%	5%					X
Natural Ventilation	90%	10%			X		
New Employed Materials	80%	20%			X		
Skilled labor	60%	40%		X			
Time to complete the project	/			X			
Existing demand for Passive House	60%	30%			X		
Cost	65%	25%				X	

Table 2

Criteria comparison between Passive House and Traditional House

Criteria	Passive House	Traditional House
Indoor air quality	Good	Normal
Energy-efficiency	80-90%	10%
Cost and affordability	105-110%	100%
New Employed materials	65%	10%
Skilled labor	70%	5%
Realization/Time	Takes long time	
Comfort	90%	30%
Methodology	New	Routine



Conclusions

This paper has explored the concept of the Passive House and how it can impact homebuilders contribute in the reduction of energy's consumption along with the improvement of indoor air quality and consumer's comfort. The objective of the study was to identify the major barriers to large-scale adoption of Passive Housing concept in the United States. Results of the study benefited homebuilders by providing recommendations on passive housing principles, clarifications, and advantages. Thereby incentivizing the home builders to challenge the existing obstacles. Reviewed data from literature and personal investigation, resulted in the following findings: Challenges of large-scale adoption of Passive House in the United States are mainly due to the lack of education, certified professionals, and unfamiliarity with the Passive House concept in the actual housing industry. In addition to the inexperienced labor which can cause major project delays and cost at the benefit of the quality and schedule. Homebuilders expressed their concerns in regard of the Passive House's marketing which is less familiar in the housing's market. Besides, the perceived additional cost and expenses to achieve the criteria which makes Passive House's cost prohibitive for most homebuilders. Furthermore, climate was expressed as a considerable constraint to meet the standards due to the wide variety of climates zones in the United States.

Most interviewed homebuilders pointed out the common trend of EarthCraft houses which is developed program by South face Energy Institute and the Greater Atlanta Home Builders Association. They tend to adopt EarthCraft standards which requires lesser strict specifications compare to the Passive House specifications. The difference between the Passive and the EarthCraft House is the level of complexity, feasibility, and the target for efficiency. As a major finding of the study, homebuilders conveyed a favoritism to the EarthCraft house concept rather than the Passive House due to their familiarity and knowledge of the concept.

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