Energy and Buildings 62 (2013) 368–380

Contents lists available at SciVerse ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Eco-houses and the environment: A case study of occupant experiences in a cold climate

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ARTICLE INFO

Article history:
Received 3 September 2012
Received in revised form 7 January 2013
Accepted 9 March 2013

Keywords:
Eco-houses
Residential energy
Household survey
Dwelling characteristics
Energy efficiency behavior
Green technologies
Eco-friendly activities
Sustainable lifestyles

ABSTRACT

In many markets where few eco-houses have been built, potential purchasers have little locally-relevant information regarding these types of dwellings. To address this information gap for cold climate markets, we report on the results of a recent survey of occupants of eco-house units in and around Edmonton, Alberta, Canada. Participating households included those fully involved in the design, choice of technologies, and construction of their homes, and others who purchased an already completed dwelling. Survey findings reveal general satisfaction both with pre-occupancy support received from specialist contractors, municipal government, and neighbors, and with post-occupancy dwelling performance. Perhaps surprisingly, survey participants did not generally consider their decision to acquire an eco-dwelling to be more risky than selecting a conventional dwelling equipped with more familiar technologies. Although the purchase price was somewhat higher than for a conventional dwelling, few considered it to be substantially more expensive. Pre- and post-occupancy behavior comparisons mainly show an increased uptake of practices that are energy-reducing and eco-friendly. However, in some instances behaviors switched in the opposite direction, possibly due to the awareness of households that they were using more environmentally friendly energy sources. None had yet achieved net zero energy performance from their homes.

1. Introduction

The development of a sizeable Canadian eco-house market could potentially assist efforts to control residential sector greenhouse gas (GHG) emissions. Currently, however, energy-efficient eco-house units designed to substantially reduce the direct and indirect consumption of fossil fuels (oil, gas, coal) by residents form only a very small niche market in Canada, partially spearheaded by efforts such as Canada Mortgage and Housing Corporation's (CMHC) EQuilibrium™ Sustainable Housing Demonstration Initiative.[1] The most efficient of these eco-houses are designated as *NetZero* homes, as they are (theoretically) capable of producing at least as much energy as is used by their occupants for heating, lighting, and in-home household production and leisure activities over the course of a year, where actual *net zero* achievement depends on design characteristics, occupant behavior and weather conditions.

Among the potential barriers to expansion of eco-houses beyond a niche market in Canada is consumer acceptance of this form of housing. While an increase in up-front capital costs of construction or purchase compared to standard housing may be obvious, the fact that eco-houses currently form a niche market means that potential purchasers have relatively little knowledge of the actual as opposed to potential energy cost savings that are likely to be achieved by living in an eco-house, and of how satisfied they would likely be with eco-house living. In addition, issues such as possible difficulties in dealing with builders or municipal authorities when constructing eco-houses as compared to standard housing, or with special financial incentives or additional risk factors, also add to the set of consumer uncertainties that may dissuade them from seriously considering eco-houses as an option. Finally, especially, but obviously not only, in a Canadian context, concerns with whether experiences with eco-houses in other jurisdictions are likely to be replicated in the colder Canadian climate may also be a factor that acts to prevent expansion of its eco-house market.

Our objective in this paper is to provide some information on the issues identified above, and in particular to examine the extent to which consumer acceptance is likely to be a barrier to expansion of eco-housing beyond its current niche market status, particularly in a cold climate. Given the relatively small amount of eco-housing in Canada, and the fact that it is mainly quite new,

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[1] http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/eqho_008.cfm (last accessed July 9, 2012)

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http://dx.doi.org/10.1016/j.enbuild.2013.03.018

it is not possible to simply compare information from residents of the two types of housing. To begin, no such survey data exist,[2] and the survey information on Canadian housing that is typically collected does not address many of the issues of interest concerning eco-houses. Therefore, the approach we have taken is akin to a case study where the experiences of a relatively small sample of eco-house residents, with a focus on the issues described above, are examined via a detailed in-person survey. Drawbacks of this approach include the relatively small sample size, making generalizations to the population as a whole difficult, and the lack of a formal control group with which to compare the results. However, the eco-house market in Canada is very small, so that at best a small amount of information is all that potential purchasers have when making their decisions, and to date, this information is not readily available. Further, while a control group would be useful, the small sample size (comprising varied designs and technologies) – since there are relatively few eco-house residents and no standard design – would still provide statistical challenges, and it is likely that many potential house purchasers are already aware of issues associated with purchasing standard housing, so an emphasis on the experience of eco-house residents may provide the additional information needed to better evaluate the eco-house purchase option.

Our data consist of responses to a detailed survey of residents of eco-houses in and around Edmonton, Alberta, Canada conducted between October 2011 and February 2012 via in-person interviews carried out by the Canadian Building Energy End-Use Data and Analysis Centre (CBEEDAC). This particular location, at latitude 53°, creates challenges for the design and operation of energy-efficient dwellings as it offers a relatively harsh winter climate. In 2011, there were 5097 heating degree days but only 56 cooling degree days. The corresponding values for 2010 were 5001 and 61, respectively.[3] It is hoped that by shedding light on the pre- and post-occupancy experiences and behaviors of these survey participants, a better understanding might be obtained of the potential for a large-scale eco-housing sector in parts of Canada (and other countries) facing similar climate challenges.

As alluded to above, a wide variety of designs and technologies can be found in our sample of homes, which range from *NetZero* designated houses that incorporate a variety of active and passive solar and other features, to highly-efficient homes that utilize solar, geothermal and/or co-generation technologies to meet part of their heating and other energy requirements. In addition to being diverse in terms of the technologies used, the 13 households who participated in the survey vary in terms of the degree to which they were involved in the construction of the dwelling, their attitudes toward risk, family demographics, and their behaviors before and after occupying a highly energy-efficient dwelling.

The remainder of this paper is structured as follows. In Section 2, general issues surrounding the development and evaluation of eco-houses are considered. Section 3 discusses the survey instrument. Selected results from the survey data, including comparisons with data from the most recently available national survey of household energy use, are presented and discussed in Sections 4 and 5, with the former focusing primarily on observed dwelling and occupant characteristics and the latter on post-occupancy behavior. Section 6 briefly comments on the usefulness of the data gathered for potential eco-house purchasers – particularly in a cold climate, but possibly with wider applicability – while Section 7 concludes.

2. Development and evaluation of eco-houses

In some areas, the construction of eco-houses has occurred on a relatively large scale. For example, a San Diego (USA) developer built and sold over 300 highly energy efficient homes in two communities [1]. There are also about 500 energy efficient 'passive housing' units in and around Vienna, Austria (see studies cited within [2]). In many other locations such as Canada, though, the development of energy efficient houses, although increasingly popular, remains slow, and eco-housing options are mostly limited to specialized builders and environment-minded residents.

Lovell [3] observes that while the demand for eco-housing in the UK has increased, the supply of such dwellings is limited. The specialized building techniques and materials used in these buildings can limit the attractiveness of these houses for most mainstream builders, given the numerous real or perceived technical and cost-related obstacles. Factors such as expectations of higher construction costs, lack of technical expertise, low rates of institutional innovation and the relative ease of finding buyers for (often) less expensive conventional dwellings, reduce incentives for builders to adopt the innovations required for the construction of energy-efficient structures and help to explain the small number of contractors willing to undertake energy-efficient projects [3–5].

As a result, many eco-houses are found in the self-built sector. Smith [6] explains that this form of development, initially in niche markets, can benefit the mainstream residential construction sector as it provides opportunities for learning and gaining experience in specialized building techniques, and in the use of new green technologies, in an environment where agents are often motivated by considerations beyond cost effectiveness or convenience. Niche development, in effect, has the potential to create positive spillovers as it permits the diffusion of information and an increased awareness of available technologies and techniques. It is also most likely to lead to more widespread adoption if support is available to potential subsequent market participants who are likely to be more concerned with finances and proven methods. Note that many of the dwellings included in the CBEEDAC survey discussed in the next section have been used as demonstration homes and/or made available for public tours.

Another reason for the current niche market status in many locations is that the designs of eco-houses are difficult to standardize as they can involve the installation of a variety of features and technologies, with the set of viable candidate technologies varying by climate and geography. For example, although many of the EQuilibrium™ demonstration houses utilize solar energy-based designs, one of the earliest studies of eco-housing in Canada examines the feasibility of net zero housing design in rural Newfoundland, with an emphasis on wind-based electricity generation combined with battery storage, noting that local weather patterns render solar technologies incapable of providing sufficient amounts of energy [7]. In Edmonton, on the other hand, an urban setting hundreds of kilometers north of Alberta's prime wind resources, wind-based generation would not be a feasible option.

Anderson et al. [8] along with Kerr and Kosar [9] find that energy efficiency improvements are most costly in cold climates such as Chicago (USA), with the latter noting that achieving high energy efficiency in such a climate zone "pushes the limit of today's technologies and designs." The location considered in our study (Edmonton, Alberta, Canada), being colder than Chicago, offers similar, and possibly more severe, challenges. Although there are ample spring and summer daylight hours, making solar energy designs obvious candidates in terms of technologies, winters are harsh and offer fewer than 8 h of daylight at some points of the year [10].

On the demand side, decisions of home-buyers will be affected by various factors that may discourage them from investing in highly energy-efficient dwellings. Among the reasons commonly

[2] The last broad survey of household energy use in Canada was conducted in 2007, and to date only aggregated data from that survey have been publicly released.

[3] See http://edmonton.weatherstats.ca (last accessed April 2, 2012).