Applied Energy 89 (2012) 329–338

Contents lists available at SciVerse ScienceDirect

Applied Energy

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

Implementation of energy-efficient windows in Swedish single-family houses

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ARTICLE INFO

Article history:
Received 15 February 2011
Received in revised form 18 July 2011
Accepted 24 July 2011
Available online 6 September 2011

Keywords:
Energy-efficient windows
U-value
Homeowners
Sellers
Installers
Sweden

ABSTRACT

A questionnaire survey of 1010 homeowners in Jämtland and Västernorrland, which are two counties in central Sweden, was conducted to understand the factors influencing their decision to install energy-efficient windows. We complemented this survey with an interview of 12 window sellers/installers in the county Jämtland. The annual energy cost reduction, age, and condition of the windows were the most important reasons for the window replacement decision. Approximately 80% of the respondents replaced their windows with energy-efficient windows with *U*-value of 1.2 W/m^2 K. Condensation problems, perceived higher prices, and lack of awareness about windows with lower *U*-values were important reasons for non-adoption of more energy-efficient windows. Window sellers/installers have a strong influence on homeowners' window selection that was indicated by the 97% of homeowners who bought the windows that were recommended to them. Sellers/installers revealed that they did not recommend windows with *U*-value of less than 1.2 W/m^2 K because they thought that investing in such windows was not economical and because windows with *U*-value less than 1.2 W/m^2 K could cause water condensation on the external surface of window pane.

1. Introduction

About 85% of single-family houses in Sweden are more than 30 years old [1]. Windows in many of these buildings are old and have low levels of energy efficiency because these buildings were built before energy efficiency was emphasised in the building code in 1977.[1] Hence, there is a large potential to install energy-efficient windows in existing single-family houses. Approximately 15 TWh of heat is lost annually through the windows of Swedish residential buildings [2]. Windows have a long lifespan and therefore, the type of windows installed will influence the energy use of the buildings for a long time. Investment in energy-efficiency measures is often cost effective during renovation [3]. When existing building components, such as windows, have to be replaced, it is cost efficient to replace them with an energy-efficient component [4]. This decision reduces the primary energy use and helps mitigate climate change.

A Swedish national survey of owners of single-family houses in 2008 showed that about 30% of homeowners intend to replace their windows over the next 10 years [5]. Adoption of new windows may be influenced by such factors as intention to reduce energy cost, investment cost, durability aspects of the windows, and condensation issues. Condensation in energy-efficient windows is a phenomenon of water condensing in the external surface of windows, which decreases the visibility. External condensation usually occurs for windows that have a *U*-value of $\leqslant$1.3 W/m^2 K, and the phenomenon is more frequent for lower *U*-value windows [9]. The condensation is visible usually during the morning in the spring and autumn when the air is very humid and the temperature fluctuations between day and night are high [9]. According to Werner [2], the daytime condensation hours could be reduced significantly by lowering the emissivity from 0.85 to 0.3 by tin oxide coating. Though external condensation is a sign of well insulated windows, for many people, it is a disturbing and unacceptable sight; therefore, they may refrain from buying such windows [2]. Window manufactures are also apprehensive to sell low *U*-value windows due to condensation issues [9].

Homeowners' final choice of which windows to purchase is influenced by external factors, such as investment subsidies and the marketing efforts of sellers/installers. During 2006–2008, to promote energy-efficient windows (*U*-value $\leqslant$ 1.2 W/m^2 K) in single-family houses, the Swedish government provided investment subsidies of 30% of the costs exceeding 10,000 SEK.[2] The ceiling for the investment subsidy was 10,000 SEK per household. From January 2009 onward, a tax subsidy (ROT programme) has been available for homeowners, and they can claim 50% of the labour costs

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[1] In 1977, a supplement of Swedish building code (SBN75) stipulated the *U*-value of windows as 2.0 W/m^2 K [6]. Compared to many other countries, the energy-efficiency standard for windows is advanced in Sweden. For example, in Sweden, a window is considered energy-efficient if its *U*-value is $\leqslant$1.2 W/m^2 K [7], while in Denmark the *U*-value for such windows is $\leqslant$1.8 W/m^2 K [8].

[2] 1 Euro = approximately 9.1 Swedish Kronor in June 2011.

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doi:10.1016/j.apenergy.2011.07.040

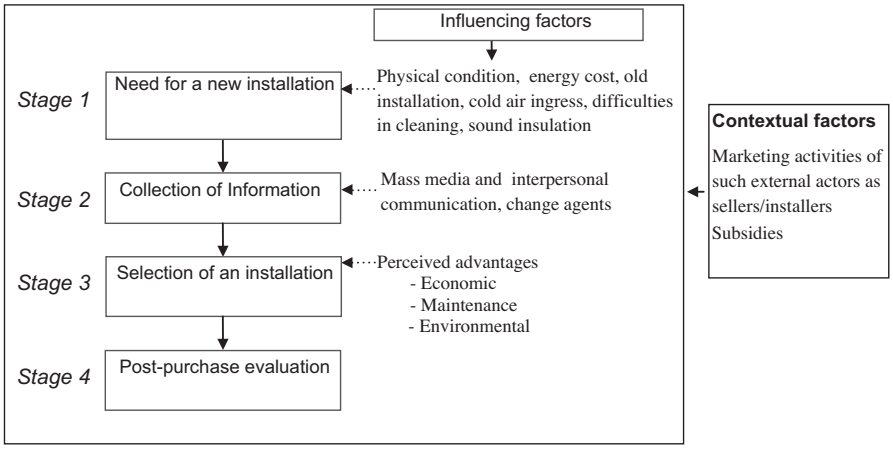

Fig. 1. Schematic representation of different stages of decision-making in homeowners' adoption of energy-efficient windows, adapted from [10–13].

(up to 50,000 SEK/person/year) for household renovation, which includes the adoption of new windows or repairing existing windows.

Swedish homeowners consider sellers/installers to be one of the most important sources of information in their adoption of energy-efficient building envelope components [5]. The seller/installer's influence, in turn, is guided by their awareness, attitude, and expertise, as well as their respective interests.

The objective of this study is to better understand homeowners' adoption of energy-efficient windows, particularly the role of window sellers/installers and the influence of the investment subsidy.

2. Theoretical framework

A typical purchase decision for an installation passes through four stages: need creation, collection of information, selection of an installation, and post-purchase evaluation. A schematic representation of the decision making process for adoption of energy-efficient windows is given in Fig. 1.

Demographic variables, such as age, income, and education, may influence potential adopters' decision processes [10]. Socio-demographics may be useful in understanding the environmental knowledge and attitude of individuals [14] and, therefore, the market segmentation of potential adopters [15]. Still, there is no conclusive evidence regarding the relationship between demographic factors and *green* consumer behaviour [14,16,17]. Some Swedish studies have shown that there exists a relationship between homeowners' ages and their energy-efficient behaviour [11,18,19].

2.1. Need for a new installation

The need for a new system or product is triggered by recognising a problem with the existing system or product. The consumer will engage in activities to avoid the problem or to reduce its effect. The homeowner's decision process to purchase new windows begins when the homeowner identifies some problem with their existing windows, and window replacement is usually the culmination of the problem recognition. A need for the replacement of an existing window arises due to several factors, such as the physical condition of the windows, higher energy cost, cold air ingress from windows, poor sound insulation, and difficulty in cleaning windows. Homeowners who felt a need for new windows could select either conventional windows or energy-efficient windows. A need for an energy-efficient window may be guided by the desire to reduce energy use. However, homeowners may not buy energy-efficient windows, due to low awareness or perceived high investment costs or condensation issues associated with such windows.

2.2. Collection of information

Prior to a purchase decision, consumers usually conduct an external information search, which may include accessing information from mass media, interpersonal sources, and sellers/installers, as well as from neutral sources, such as municipal energy advisers. Though mass media could improve consumers' awareness about various products, their ability to influence consumers' adoption decisions is limited to a small group of innovators and early adopters [12]. Home-delivered brochures and leaflets were less important for homeowners in their adoption of energy-efficiency measures [5]. For high investment cost decision-making processes, customers' preferences for extended or limited external information search depends on their perception of the costs associated with the search [10] and their ability and motivation to do the information search [20]. In any case, external advice may help the potential consumer to improve their decision confidence [21]. Individuals give more weight to advice while performing a difficult task [22] and this preference may be the case for the adoption of investment intensive energy-efficient measures, such as windows.

2.3. Selection of an installation

Once homeowners perceive that they have sufficient information about the product and alternative solutions, they may decide to choose an option that best fits their needs. The purchase decision is preceded by an alternative evaluation stage. Various factors, such as condensation issues, investment cost, energy cost savings, improved sound insulation, durability, and ease of cleaning the windows could influence homeowners' adoption of new windows.

2.4. Post-purchase evaluation

Homeowners' major purchase decisions, especially those with long-term consequences, are more likely to create mental stress [10,23,24]. To avoid such angst, consumers will try to confirm the purchase decision through various means, such as ignoring dissonant information, lowering the expectation, and selectively interpreting the information [25]. If the concerns due to condensation issues, for example, are small, homeowners' post-purchase evaluation of window replacements could be influenced by their desire to avoid or reduce the severity of the issue. However, if the disparity in expected and actual performance is high, home-