Let the Sunshine In (or Keep It Out): Evaluating an Energy Star Windows Program

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Introduction

Windows represent a major source of unwanted heat loss and heat gain in residential dwellings. Energy Star windows can substantially reduce windows-related HVAC loads while increasing resident comfort. The purpose of the evaluation is to conduct a process, market and impact evaluation of the residential Energy Star windows program conducted by BC Hydro which provided rebates covering both residential new construction and retrofits. Given the range of issues examined in the evaluation, the study employed multiple lines of evidence and multiple analysis methods. Data sources included pre-program market research, trade ally interviews, survey of some 800 customers who purchased windows, and on-site audits. Data analysis included t-tests for sample differences in survey data responses, structural equation modeling of the windows market using two stage-least squares regressions with first-order autocorrelation, and energy modeling, using RESFEN simulation software.

Key Results

Program Review. Before program launch, BC Hydro Power Smart conducted detailed baseline research to understand the nature of the windows markets for new construction and for retrofits. This research found that the share of Energy Star windows sold in the combined retrofit and new construction market was less than five percent. This research also identified several barriers to increased sales and market penetration of Energy Star windows. The rationale for the program was to address these barriers through an integrated and coordinated set of program activities. Based on interviews with program staff, a review of program documents, and the literature review, we identified four main program activities: (1) window certification support; (2) manufacturer and retailer support; (3) advertising and other promotions; and (4) manufacturer window incentives. For each of the four sets of activities, the summary logic model documents the chain from inputs to outputs to purposes to goals. In other words, the model says that at each level of the logic if the assumptions are met, then the next level of the logic will be achieved. Our assessment is that each of the logic chains is plausible and realistic. We therefore conclude that the program has a valid and realistic program rationale.

Demand Side Assessment. The demand side market assessment is based primarily on a survey of 800 BC Hydro customers who purchased windows as part of a renovation and participated in the Power Smart windows program. Customers were asked a variety of questions about their levels of satisfaction with Energy Star windows and the windows program. The share of customers who were either satisfied or very satisfied with various attributes is as follows: overall satisfaction with the Energy Star windows program (68%); knowledge of the window contractor (79%); choice of windows qualifying for the rebate (70%); information available on the Energy Star windows program (66%); information available on Energy Star windows (69%); and satisfaction with Energy Star windows (95%). Customers were asked the relative importance of various attributes in their choice of windows. The share of customers who said the reason was either important or very important is as follows: comfort in your home (93%); energy efficiency (92%); appearance (82%); initial cost of window (66%); noise transmission (68%); and ultraviolet light transmission (59%).

Supply Side Assessment. The supply side assessment is based primarily on a series of surveys of BC windows manufacturers, in particular, the most recent survey which was conducted in June 2008. The number of windows manufacturers producing Energy Star Windows in British Columbia increased from 5 in June 2005 to 19 in September 2008 and to 27 in May 2008. Windows manufactures were asked a variety of questions about their levels of satisfaction with Energy Star windows and the windows program. The share of manufacturers who were either satisfied or very satisfied with various attributes is as follows: overall program satisfaction (50%); frequency of communications from BC Hydro (50%); display and promotional materials provided by BC Hydro (50%); opportunities for co-operative joint advertising with BC Hydro (39%); processes an procedures to certify windows as Energy Star windows (39%); effectiveness of BC Hydro's education awareness campaign (28%); and BC Hydro's sales training in Energy Star windows (17%).

Sales and Price Impacts. We apply a simple demand and supply model in which the price is established to clear the market, that is, the quantity demanded equals the quantity supplied at the market clearing price in each year t. The demand equation for the total windows market has an excellent fit, with an adjusted R-squared value of 0.98, and all of the regression coefficients are statistically significant:

(1) $\text{ES area}_t = 28{,}680 + 44{,}300 \cdot \text{Starts}_t - 237 \cdot \text{Price ratio}_t + 2{,}440 \cdot \text{Program}_t + \text{error}_t$

This equation says that for glazing in new residential construction, an increase of 1,000 housing starts increases Energy Star glazing area by 44,300 square feet, a doubling of the Energy Star to non-Energy Star price ratio reduces Energy Star glazing area by 237,000 square feet, and the presence of the Power Smart windows program increases the Energy Star glazing area by 2,440,000 square feet in F2008 and by 4,880,000 square feet in F2009. The supply equation for the total market has a good fit, with an adjusted R-squared value of 0.72, with two of the three coefficients statistically significant:

(2) $\text{Price ratio}_t = 1.26 - 0.022 \cdot \text{Trend}_t - 0.051 \cdot \text{Program}_t + \text{error}_t$

The equation says that for the unit price of Energy Star windows, price falls by 2.2% per year but the coefficient on the program variable is not statistically significant which means that the current program has no independent impact on price.

Energy and Peak Impacts. We estimate unit energy savings by developing a series of archetypes for 36 scenarios with and without Energy Star windows. The scenarios are modelled using the Lawrence Berkeley National Laboratory's RESFEN 5.0 windows modelling software. The estimates of energy savings are expressed as weighted averages for the three Energy Star climate zones and for British Columbia as a whole. Savings were then normalized on a per square foot basis and multiplied by the relevant incremental window area from the sales analysis. Incremental electricity energy savings were 6.6 GWh per year for F2008 and 13.3 GWh per year for F2009. Incremental electricity peak savings were 1.4 MW for F2008 and 2.9 MW for F2009. Incremental natural gas savings were 75.9 TJ per year for F2008 and 151.8 TJ per year for F2009. Incremental natural gas peak savings were 392.9 GJ per day for F2008 and 785.8 GJ per day for F2009.

Cost Effectiveness. We examine cost effectiveness of Energy Star windows in terms of the pay-back period disaggregated by main space heating fuel and by climate zone. Note that the cost effectiveness analysis is based on the incremental technology costs before incentives plus program costs. The incremental unit technology cost is the estimated cost of improving the base window to the Energy Star standard for the climate zone. The unit program cost is total program cost divided by the incremental number of units. For electrically heated houses, the pay-back period is 2.9 years in Zone A, 1.6 years in Zone B, 1.7 years in Zone C., with an average of 2.8 years. For natural gas heated houses, the pay-back period is 4.9 years in Zone A, 2.7 years in Zone B, 3.0 years in Zone C, with an average of 4.4 years.