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Case Studies of Major Home Energy Retrofits

INTRODUCTION

New annual housing starts in Canada in recent years represent less than 2 per cent of the existing housing stock. If Canada addresses the energy consumption of new dwellings only, it will not achieve the greenhouse gas emissions targets of the Kyoto Accord.

This project was designed to produce clear and demonstrable energy savings in existing housing through energy retrofitting so that these houses could be used as benchmarks for energy savings. The general target was that the post-retrofit house energy consumption, from all sources, should be at least 40 per cent lower than the pre-retrofit levels.

Space heating is the largest end use of energy in Canadian residences at 62 per cent, while water heating represents 22 per cent. Due to the relatively low cost of natural gas in some areas, the cost for electricity energy for lighting and appliances can match or exceed the cost of natural gas for space and water heating. Thus, all energy using devices in the studied homes were investigated for energy savings.

RESEARCH PROGRAM

Five homeowners were located that were willing to undertake the recommended retrofit measures at their own expense. The houses were different in style, age, size, occupancy and initial condition.

Pre-retrofit house characterization, testing and documentation were performed. This included blower door testing measurements of house physical dimensions, combustion efficiencies and appliance electrical use, as well as HOT2000 computer (Version 8.5) modelling. Utility records for the pre-retrofit periods (electricity, natural gas and water) were obtained for the HOT2000 modelling and graphing of utility use.

Using the HOT2000 models, retrofit plans for each house were developed to meet the performance goal. Homeowners were provided with a list of necessary changes.

The major changes to the five houses and the actual installed costs are presented in the following table:

Table 1

Measure	House D1	House G1	House G2	House G3	House G4
Furnace	Mid efficiency 22.0 kW $1,900	High efficiency 17.5 kW $3,455	High efficiency 17.5 kW $3,335	High efficiency 17.5 kW $3,500	High efficiency 22.0 kW $3,500
Water Heater	Insulate existing tank $50	Power vent–insulate tank $1,115+$50	Power vent–insulate tank $1,115+$50	Power vent–insulate tank $1,425+$50	Power vent–insulate tank $1,100+$50
Chimney	Leave as is	Eliminate	Eliminate	Eliminate	Eliminate
Basement Wall	Frame/insulate $1,500	Frame/insulate $1,730			Finish insulating**
Attic Insulation		Add RSI 3.3 $150	Add RSI 3.3 $150	Add RSI 2.8 $350	Add RSI 2.8**
Windows	Add acrylic pane**	Add acrylic pane**	Add acrylic pane**		
Air Sealing		Yes–costs included in Basement Wall	Yes–$5 Modelled for 3.8 ACH@50Pa –achieved 7.2 ACH@50 Pa		Yes–$25 Modelled for 4.0 ACH@50Pa –achieved 5.7 ACH@50Pa
New Major Appliances					
Refrigerator(s)	Replace and remove second one $860		Replace refrigerator, clothes washer, dryer, freezer $2,555	Remove second one $0	Replace $1,100
Clothes Washer		Front loading and dryer $1,680		Front loading $1,095	Front loading $1,050
Dryer					
Freezers				Replace $600	
CFLs*	Yes–$90	Yes–$20	Yes–$155	Yes–$175	Yes–$270
Water Conservation Measures					
Toilet Dams		Install $10	Install $10	Install $30	Install $20
Low Flow Shower-heads	Install	Install $20	Install $20	Install	Install $20
Other					
Entrance Doors			$1,910		

* compact fluorescent lamps ** not implemented

Post-retrofit characterization, testing and documentation were performed. This included blower door testing, measurement of furnace and water heater combustion efficiencies, measurement of electrical consumption of new appliances and furnace blower motors, counting of new CFLs, characterization of furnaces including temperature rises, pressure drops and motor operation, measurement of hot water temperatures, cost of retrofit measures, and clothes dryers and exhaust fans air volumes.

Using meter readings taken by the homeowners and by SRC staff, comparisons were made of the post-retrofit energy consumption to the pre-retrofit energy consumption. Post-retrofit meter readings were taken starting in the winter of 2001/2002 through to the project end (December 31, 2002) at a minimum of once per month and as often as once per week (most cases).

The natural gas and electricity consumption values for the pre-retrofit and post-retrofit periods for all of the houses were normalized to 6,077 degrees Celsius annual heating degree days, the long-term annual average figure for Saskatoon.

FINDINGS

The energy reduction for each of the five houses after the retrofit measures were implemented are presented in the following table. The values in the table have been normalized to the long-term annual average heating degree days for Saskatoon (6,077 °C-d base 18°C).

	D1	G1	G2	G3	G4
Natural gas consumption reduction, %	30.4	45.0	29.0	27.5	25.9
Electricity consumption reduction, %	9.1	2.4	15.4	40.8	6.4
Total energy consumption reduction, %	26.5	39.9	26.9	30.8	23.9

The post-retrofit date of December 2001 was used as the start for all of the post-retrofit calculations. Heating degree-days were 12.8 per cent higher in 2002 (6,044.9 HDD) than in 2001 (5,358.8 HDD).

The project objectives of 40 per cent savings were attained in one house; one house was in the 30 per cent range; and the lowest at 23.9 per cent (when looking at the annual heating degree days normalized data).

All of the homeowners were satisfied with the project and the levels of savings. House G4, with the lowest percentage savings, appreciated that 40 per cent was not attained because of the furnace size and type he chose (larger than recommended) and because of his lifestyle changes.

Based on the savings achieved and the amount of money spent by each of the homeowners to perform the retrofits, the simple payback periods ranged from 8.4 to 16.5 years (using the current utility rates). There were a few simple reasons why three of the houses have payback periods longer than 10 years. One of the houses did not perform all of the retrofit measures and some of the equipment installed was not sized according to the recommendations. Another house with a longer payback period had very low utility bills to begin with, reducing the dollar value of saving 40 per cent of total purchased energy. The third house purchased expensive exterior doors and more appliances than were recommended.

Homeowners were very interested to see how much electricity was being consumed by their major appliances. House G3 will pay for their new freezer in three years with the electricity savings.

The project provided impetus for House D1 and G1 to complete their basements making them more comfortable and usable.

There were a few major deficiencies and lessons learned. The actual measured combustion efficiencies of the new furnace were lower than manufacturers' claims. Modelled reductions in air tightness levels were not achieved.
In some cases the homeowners did not complete all of the recommended retrofit measures. The utility-supplied water temperature in Saskatoon for the winter of 2002/2003 was colder than normal due to maintenance being performed by the water company. The computer model predicted savings and the actual savings were not always in agreement. Model input values, such as levels of air tightness and expected electricity usage, were not attained. The new power vented water heaters used electricity for the vent motors which was not in the model.

House G4 purchased a larger-than-recommended furnace with a large blower motor. Any savings in electricity from the new appliances were eliminated by the new furnace fan motor. This house did not add attic insulation as recommended but the style of the house would not have allowed much to be added regardless.

House G3 was initially reluctant to unplug the refrigerator in the basement but consented to do so during the post-retrofit period. House D1 refused to unplug the basement refrigerator. For this house, HOT2000 predicted that a mid-efficiency furnace would be sufficient to attain the 40 per cent savings if the combustion efficiency could have been raised to 85 per cent. This proved to not be attainable. This house also continued to use continuous fan circulation on the furnace. This was the single largest electrical load in the house.

IMPLICATIONS FOR THE HOUSING INDUSTRY

This project has shown that residential retrofitting can be very effective in reducing energy consumption. The use of the correct space heating equipment and major electrical appliances, at a nominal incremental cost, can provide substantial energy savings at attractive simple payback periods.

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