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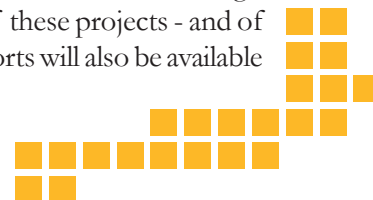
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Recent CBEEDAC Research

Each year, researchers at CBEEDAC undertake a number of methodology projects, some of which are directly concerned with modelling some aspect of energy use and/or energy efficiency in the buildings sector - that is residential, commercial, and institutional - and others that are more concerned with trying to understand, or examine the implications of, various energy data issues that arise. In this issue we report on a sampling of the projects that we have worked on in the past year, with some selected from each of these categories.

In the former category, work has continued on analyzing aspects of the EnerGuide for Houses database. This data set, collected from voluntary pre-retrofit energy audits of houses across Canada, as well as post-retrofit energy audits for homeowners who chose to undertake some retrofits and a follow-up energy audit, contains detailed information on energy efficiency properties of houses, but unfortunately almost nothing on homeowner characteristics. Of course, energy consumption and efficiency is the result of the interplay between these two sets of factors. To attempt to investigate this issue, one of the projects that is briefly summarized here involves incorporating Canadian census data with the audit data, matched by house location. Other projects in this category, for which brief summaries are provided, include an investigation of the ownership and use of programmable thermostats, analysis of major appliance replacement in Canada, and analysis of the limited data available on Multi-Unit Residential Buildings. As an example of a project in the latter category, we report here on an analysis of discrepancies between sales and changes in stocks of residential air conditioners.

Of course in the limited space available here we can only provide brief synopses, and cannot cover all of the projects with which CBEEDAC researchers and graduate students were involved. Other recently-completed projects not detailed here include energy use for residential water heating, the possibility of energy consumption misclassification by sector in Canada, and estimation of site-specific residential electricity consumption in the absence of meter readings. We hope to be able to provide further details of some of these projects - and of those just briefly reviewed here - in future issues. Full reports will also be available on our website.





A Sampling of Current CBEEDAC Projects

The EnerGuide for Houses (EGH) Retrofit Incentive Program

Participation, Energy Cost and Energy Consumption Savings

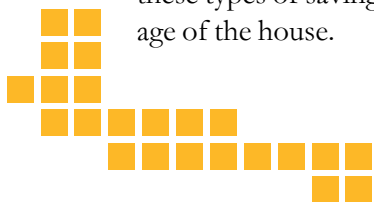
Using information on the stock of houses in each province and its age distribution, the purpose of this project is to analyze the participation rates in the Canadian EnerGuide for Houses (EGH) retrofit program of owners of different types of housing of different ages in each province. Under this program – which (with various changes) ran from 1999 to 2005, with a modified version having a slightly different name currently in existence today – homeowners undertake an initial energy audit of their home at their own expense (although in some cases these audits are subsidized). Based on the audit they are provided with energy-saving retrofit recommendations which they can follow fully, partially, or not at all. If they wish, homeowners can undertake a (typically less expensive) follow-up audit to evaluate the energy savings they have achieved via any retrofits that they undertook, and provided sufficient energy savings are achieved, homeowners may qualify for a grant.

In addition to homeowners that participated in the first home energy evaluation (audit), participation rates are also determined for homeowners who undertook energy-saving retrofits and completed the second energy audit. As well as participation rates, the energy cost and consumption savings that resulted from the retrofits are also investigated for different provinces, house types, and house age groups. We find that participation rates in both the first and second home energy evaluations tend to be highest in Western and Central Canada, for single detached houses, and for houses built before 1960. Energy cost and energy consumption savings are found to be larger for the Atlantic Provinces, which had the lowest participation rates in the EGH program, although in general, rankings of energy consumption savings by location do not mirror the rankings of energy cost savings by location. Single detached houses have the largest energy cost and energy consumption savings, and generally both of these types of savings are found to increase with the age of the house.

Utilization: Who, What & Why

A potential concern with the EGH program is that only a relatively small percentage of homeowners participating in the first audit undertook (some of the) recommended retrofit upgrades and the second audit. The fact that houses that underwent both audits are generally characterized as having relatively severe energy-inefficiency problems is encouraging in the sense that potential energy savings are found to be the main driver behind participation in the program in the first place, and those with larger energy-saving potential proceeded to undertaking actual retrofit upgrades. Hence, energy-saving is the reason *why* homeowners participate in EGH retrofit program and undertake retrofit upgrades on their homes, and homeowners with houses that have poor energy efficiency conditions and therefore higher energy-savings potential are the ones *who* undertake retrofit activities. Among houses that actually underwent retrofit investments, those with greater energy savings potential generally underwent a larger number of the various upgrades recommended by EGH auditors.

By augmenting the EGH data, which lacks information on demographic characteristics, with information obtained from the Canadian census, matched by location to houses included in the EGH dataset, the objective of this project is to shed light on the effects of demographic and socio-economic factors such as education, income, and age composition of household members on EGH program participation and retrofit activities. In the estimation of the probability of undertaking at least one upgrade, income, level of education, and age composition of household members are found to be important determinants of this decision. Econometric analysis aimed at determining the factors that determine retrofit activities in a multivariate setting suggests that after controlling for socio-economic characteristics such as income, as well as features of the houses and their location, capital costs and the energy cost savings are key determinants of the probability of undertaking residential retrofit activities.





Major Appliance Replacement in Canada

Data from the 2003 Survey of Household Energy Use (SHEU03) are used in this project to examine appliance replacement patterns in Canada for refrigerators, freezers, dishwashers, clothes washers and clothes dryers. The average age at which appliances are replaced is found to be lowest for dishwashers – with almost one-third being replaced before they are 11 years old – and highest for refrigerators, with almost one-third of them in use for more than 20 years before being ‘replaced’. However, energy savings from improved refrigerator technology may not be realized in the short-run since as many as 25% of households continue to use older energy-inefficient models alongside newer models when the older refrigerators are ‘replaced’. Econometric analysis indicates that the linear survival curves that are typically used in models of residential energy demand tend to overestimate the replacement rates of appliances in the older age ranges in Canada. This would lead to underestimates of the number of older appliances in use and overestimates of the energy savings that can be expected in any given period from appliance replacement. However, the finding that replacement patterns found in the Canadian data are sensitive to household characteristics, such as income, suggests that there may be scope for targeted policies that focus on lower-income households to reduce residential energy use.

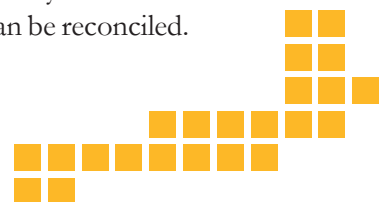
Energy Consumption and Energy Intensity in MURBs

It is estimated that approximately 31 per cent of Canadians lived in apartment buildings in 2001, with Multi-Unit Residential Buildings (MURBs) thought to account for about 24 per cent of the overall annual energy consumption within the residential sector. In this project, we use data in the HiSTAR database provided by the Canada Mortgage and Housing Corporation (CMHC) to evaluate energy consumption and energy efficiency of a sample of MURBs in Canada. Sta-

tistical analysis shows that on average, MURBs from the West Coast consumed less energy, while those from the Prairies Provinces consumed the most energy on a per square metre basis, although this may reflect climate differences rather than actual building energy efficiency. Older buildings tend to be less energy efficient (GJ per square metre), but on average use less energy per suite than newer buildings. Also, while energy intensity generally decreases with floor area, larger buildings tend to use more energy on a per-suite basis. This has potentially important implications for overall energy consumption in the sense that energy use per person in high-rise buildings may actually be increasing even as the buildings themselves become more energy efficient in terms of energy use per square metre.

Reconciliation of Sales and Stocks of Air Conditioners in Canada

Data on sales/shipments and stocks of air-conditioning units in Canada, collected from industry sources, do not appear to match very well with data on the stock of air conditioners that are obtained from household surveys. In particular, the sales/shipments in any year often are considerably different from the change in stocks from the preceding year. In addition, data from different household surveys – the annual Survey of Household Spending, and the periodic Survey of Household Energy Use – also do not appear to match very well. In this project, possible reasons for these various discrepancies are investigated. Several factors are found to contribute to the observed differences, including variation in the scope and methodology of the different household surveys, the impact of statistical sampling on the precision of the estimates from these surveys, and the impact of replacement of older with newer units on the stock of air-conditioners in use. Once these factors have been taken into consideration, many of the anomalies observed across the data sets can be reconciled.





Ownership and Use of Programmable Thermostats

Programmable Thermostats (PT) are relatively inexpensive devices that can reduce energy consumption for space heating by automatically adjusting a dwelling's temperature setting during certain periods of the day. Based on the 2003 Survey of Household Energy Use, their penetration in Canadian households is still less than 30%, although this rate has grown substantially since Canadian households were previously surveyed in 1997. PT ownership is most likely in houses that heat with forced air furnaces, is more common with those that have central air conditioning, and increases with higher levels of household income.

Almost 27% of houses with a PT maintained the same temperature through all three periods of the day – daytime, evening, and nighttime, suggesting that the expected energy savings associated with the use of PTs is not being fully realized. Except in households that set different internal house temperatures in all three of these periods, households that have a PT on average set higher average temperatures than corresponding households that did not have a PT. Over 70% of

houses that maintain the same daytime and evening temperatures are occupied during the daytime hours, while 75% of those that set the same (on average lower) daytime and nighttime temperatures are not occupied during the day.

Generally, houses with a PT were found to have lower energy intensities than those that did not have a PT and even those where the PT was not programmed had, on average, lower energy intensities than those without a PT. In addition, those households that have a PT and actually program it (do not set the same temperature in all three periods), have lower energy intensities for all fuels except propane than do those who do not have a PT, or those who have a PT but don't program it. Interestingly, however, in most cases those houses with a PT *where a different temperature is set in all three periods* do not have the lowest energy intensities. Ongoing research focuses on estimating a model of household energy intensities that controls for the effects of various other factors while assessing the significance and effect of having/using a PT.

PEOPLE

CBEEDAC has undergone a major personnel change with the departure of its Executive Director, **Donna White**. Donna has been with the centre since its inauguration in 2002, and as well as undertaking the typical duties associated with such a position, acted as a mentor and resource for the many graduate students who have worked for the centre, as well as being an active researcher. We wish her well in her new position. Currently the Executive Director position is vacant,

so please bear with us if newsletters, the web site, etc., are not as professionally produced and maintained.

Among the graduate students and graduates who have worked for CBEEDAC lately, and who have authored or coauthored some of the research papers that the centre produced, are **Matthew Hansen, Evgeny Prasol, Ronggui Liu, Samuel Gamtessa** and **Natalia Ivanova**. We are extremely grateful for their assistance.

BUILDING SERVICES

CBEEDAC has the expertise to provide services to the building sector in the area of data storage and analysis. For more information regarding these services, on becoming a sponsor of CBEEDAC, or about the services provided by other Data and Analysis Centres contact CBEEDAC or see our Web site (www.ualberta.ca/~cbeedac).

CBEEDAC reports are available online in PDF format.

If you house and/or collect data that could become a valuable addition to Canada's Building Energy End Use information system please consider contacting the Centre with your data information.

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