



C A N A D I A N
Building Energy End-Use
DATA AND ANALYSIS CENTRE
commercial • residential • institutional

Generalizing Home Retrofit Program Results to Non-Participants

Lucie Maruejols

David L Ryan

May 2009

CBEEDAC 2009–RP-04-DRAFT

*The financial support of Natural Resources Canada through the Canadian Building Energy End-Use Data and Analysis Centre (CBEEDAC) is gratefully acknowledged.

DISCLAIMER

The views and analysis contained in this paper are the sole responsibility of the author, and should not be attributed to any agency associated with CBEEDAC, including Natural Resources Canada

Executive summary

The EnerGuide for Houses (EGH) program is a voluntary environmental program established by the Government of Canada to achieve energy savings in the residential sector through retrofits of buildings. From 1998 to 2005, nearly 2% of Canadian households took part in the program and about 19% of these are known to have retrofitted their homes. When trying to assess the potential of this program for the entire Canadian housing market, problems caused by self-selection of home-owners into the program arise. Since households must decide whether or not to enroll in the program, the sample of participants is not random. Some types of households are more likely to take part in the program than others. The usual approach to dealing with the problem of non-randomness is to assess the probability of participation to the program. In the data collected as part of the program, sufficient information to build these probabilities is absent; therefore the standard method to deal with sample selectivity can not be used. This paper examines alternative methods to address the problem, drawing on additional information from a census wide survey. It also analyses the factors that influence the decision to participate in the program, as well as the factors that influence the decision to undertake renovations. Finally, some scenarios of the potential of the EGH program to achieve energy saving are presented.

Table of contents

List of tables.....	iii
List of figures.....	iii
1 Introduction.....	1
2 Sample Selectivity in the EGH Database.....	4
3 Correcting for Sample Selectivity.....	6
3.1 Typical Econometric Approach to the Sample Selectivity Problem	7
3.2 Alternative Approaches	9
3.3 An Approach to Dealing with Sample Selection in the EGH Data	11
4 Factors influencing participation and retrofit decisions.....	14
4.1 Province	16
4.2 Year of construction.....	17
4.3 House type	18
4.4 Storeys.....	18
4.5 Furnace fuel source	19
4.6 Size of the house	20
4.7 Other house characteristics	22
4.8 Income.....	24
4.9 Conclusion	25
4.10 Why households don't renovate: evidence from SHEU03	26
5 An attempt to assess the potential of the EGH program.....	28
5.1 Method	28
5.2 Scenario 1: a uniform increase in participation	30
5.3 Scenario 2: targeted increases in participation.....	32
6 Conclusion and further consideration	37
REFERENCES	39
APPENDIX.....	40
Appendix A: Variable comparison, EGH and SHEU03.....	40
Province	40
Year of construction.....	43
Type of house.....	46
Size of the house	48
Income.....	48
Storeys.....	50
Furnace fuel type.....	53
Reason for no improvement (SHEU).....	55
Appendix B: Graphs of Participation Rates.....	58
Appendix C: Graphs of Renovation rates	61
Appendix D: Graphs of Energy savings	64
Appendix E: Tables.....	67

List of tables

Table 1: Comparison of renovation rates by furnace fuel source	20
Table 2: Descriptive of quantitative house characteristics in EGH	22
Table 3: Descriptive of quantitative house characteristics in SHEU	23
Table 4: Average Canadian participation rate to EGH by category of buildings	33
Table 5: provinces eligible for a potential increase in EGH participation.....	35
Table 6: Energy saving in megajoules, before and after a 10% increase of the participation rate in EGH	67
Table 7: Results of the potential according to scenario 2	68

List of figures

Figure 1: Household Decision Tree Relating EGH and SHEU03	12
Figure 2: Footprint area of the house and renovation rate in EGH.....	21
Figure 3: Heated area of the house and renovation rate in SHEU03	21
Figure 4: Repartition of total energy saving by province	31
Figure 5: Number of additional EGH participants per province.....	35
Figure 6: Additional energy saving in megajoules per province	36

1 Introduction

The EnerGuide for Houses (EGH) program was launched in 1998 by the Office of Energy Efficiency at Natural Resources Canada in order to encourage homeowners to undertake energy-saving retrofits in their houses. This program involves two steps: homeowners/households who decide to enroll in the program undergo a first energy audit that determines the energy consumption of their house, the potential for energy-use reduction and a list of recommendations regarding retrofits that would generate energy savings. Households who decide to undertake some or all the recommended retrofits can undergo a second energy audit that will measure the energy savings that have been realized. Beginning in June 2005, households were eligible for a government grant after the second audit, with the dollar amount based on the energy savings that had been achieved.

The EGH program led to the creation of a database of information on energy consumption and retrofit activity in the Canadian residential sector. The database comprises information on energy consumption before and, when applicable, after retrofits. Information on the type of retrofits as well as the characteristics of the house is also included in the database, although almost no information concerning the household is collected. By September 2005, the EGH program had attracted a large number (188,368) of households, at least in terms of undertaking the first energy audit, but overall these houses represent a relatively small portion (just under 1.7%) of the 11,169,389 residential households in Canada in 2003.¹ Further, a much smaller number of EGH program participants (approximately 18.7%) actually completed energy-saving retrofits and undertook the second audit.² Nevertheless, at first glance the reductions in energy use that were achieved by the households that fully participated in the program (undertaking both audits) suggest that there may be considerable potential for energy-use reduction by the Canadian residential sector as a whole if more houses were to be renovated. This would

¹ References to the EGH database refer to database records as of September 2005. Information on the total number of Canadian households is obtained from the 2003 Survey of Household Energy Use (SHEU03).

² Some other households in the EGH program may have undertaken some retrofits but not completed the second audit because of the cost involved, or for other reasons.

subsequently contribute to a substantial reduction in greenhouse gas emissions by the residential sector.

Unfortunately, it is difficult to generalize the amount of energy savings that were achieved by those 35,289 households who fully participated in the EGH program to the Canadian residential sector as a whole. It may be tempting to think that if, on average, each household that fully participated in the EGH program saved X gigajoules of energy, and these households represent approximately 0.32% of Canadian households ($35,289/11,169,389 \times 100$), then there are additional energy savings of approximately $(11,169,389 - 35,289) \times X$ gigajoules of energy that can be achieved from the remaining households. This is not likely to be the case for a number of reasons, the key one being that the sample of households that fully participated in the EGH program is not random. This non-random determination of the sample is referred to as “sample selectivity”, and this information needs to be taken into account for any subsequent analysis – such as a generalization of results to the entire population – to be meaningful.

As an illustration, suppose that all households that were energy inefficient fully participated in the EGH program. In this case, there would be no additional energy savings that could be obtained for the residential sector from those households that did not fully participate in the program, so that a generalization of the energy savings achieved by full program participants to other Canadian households would be completely erroneous. While this is an extreme case, even with more realistic scenarios, similar types of problems arise when generalizing results obtained from non-random samples unless the non-randomness is taken into account. Typically, this requires additional information about the issue being addressed.

The focus of this report is on the design of a methodology that could help determine the potential for energy-use reductions by the Canadian residential sector as a whole through home energy-saving retrofits, based on the energy savings that are calculated for households that fully participated in the EGH program. To achieve this it is necessary to explicitly account for the non-randomness in the sample of full participants in the EGH program, and possibly also the non-randomness in the sample of those who undertook only the first energy audit. The approach that is developed here makes use of information contained in other Canadian household surveys.

To the extent that the sample selectivity issue can be satisfactorily addressed, the energy-saving and other information contained in the EGH dataset can be effectively generalized to the residential sector as a whole. This has potentially useful implications in terms of assessing the importance of programs such as the EGH and its successors in achieving energy-use reductions in the residential sector.³

The plan of the remainder of the paper is as follows. In the next section the various sample selectivity issues that arise with the EGH database are discussed. The typical econometric method that is used to deal with such issues is described in Section 3, which also contains an explanation of why this approach cannot be utilized in the context of the EGH database. This is followed by a discussion of various other approaches that have been considered in similar circumstances. In Section 4, an approach developed for use with the EGH data is described. Section 5 presents a method to assess the potential of the EGH program as well as results pertaining to two scenarios for the development of the program. Section 6 concludes.

³ The EGH program was discontinued in 2006 and replaced by another program, the EcoENERGY retrofit program, in April 2007.

2 Sample Selectivity in the EGH Database

Since the decision to enroll in the EGH program is voluntary, there is a very small likelihood that the households included in the EGH database are representative of the Canadian population as a whole, as some households may be more likely to participate in the program than others. Further complicating matters in terms of the EGH program, there are two separate participation decisions – whether to participate in the program at all by undertaking the first energy audit, and given that this first audit was undertaken, whether to undertake energy-saving retrofits and complete a second energy audit. Energy savings can only be determined for those households that complete both phases of the program; we refer to such households as full participants. As we explain below, in terms of sample selectivity, that is, the non-randomness of the sample that is being used for analysis, both the sample of EGH participants (who undertake at least the first audit) and the sample of full EGH participants (who undertake both audits) are subject to this problem.

Consider first the set of households from among those who undertake the first energy audit (EGH participants) who also undergo some energy-saving retrofitting and complete the second audit (full participants). If we consider which participants are likely to undertake retrofits and a second energy audit, it is immediately clear that this will not be a random sample. Based on the first audit, those whose houses could achieve little energy savings through retrofits – perhaps households that just wanted confirmation that they were behaving in an “environmentally – responsible manner”, at least as far as energy use was concerned – would be unlikely to ever complete an expensive second audit. For some other households, the recommended energy-saving measures may have indicated to them that the required retrofits would be too expensive, so that they abandoned the program. Some others may have undertaken some of the recommended retrofits, but deemed the energy savings to be too small to justify proceeding to the second audit. And for still others, the 18 month time limit between the two audits may not have provided enough time for them to afford or undertake the recommended retrofits. It would be expected that for the most part, those who undertook retrofits and completed the second audit would be those who could afford the retrofits, and who would gain the most energy savings from the retrofits, possibly because their houses were old, had little insulation, etc. This question was addressed in another CBEEDAC report (Ryan, 2009). The key point is that participation in the

second audit from among those who undertook the first audit was not random. Fortunately, in this case, the sample selectivity can be addressed in a relatively straightforward manner through the econometric method described in the next section. This is possible because the EGH database contains information on those who completed both energy audits as well as those who only undertook the first audit.

Now consider a household's decision of whether or not to participate in the EGH program at all, by undertaking the first energy audit. The outcome of this decision will depend on the net benefits they expect that they will obtain, which include the house-specific energy consumption and recommended retrofit information that is provided, as well as the household's preliminary expectations concerning any grant they may receive and energy savings that the retrofits they undertake will provide, the cost of the audit, and possibly the expected cost of any retrofits that they may need to undertake. Because these net benefits depend on the characteristics of each house and household, they necessarily differ across households. Therefore the decision to participate is influenced by household and house characteristics, so that the sample of those who undertook the first energy audit and therefore appear in the EGH database is likely not random. In particular, we expect environmentally-aware households to be more likely to enroll in the program than "average" households, while those households with low energy efficiency, high energy consumption, or with old houses that have a greater need for renovations are also more likely to be involved in the program. Of course, households with higher incomes – necessary to afford the audits and retrofits, and higher education – to be more aware of the program itself and the benefits of participating, are also more likely to be involved in the EGH program.

The difficulty with dealing with the non-randomness in this case is that the EGH database only contains information on those who undertook the first energy audit. As explained in the following section, correcting for sample selectivity typically requires information on both participants (those who did the first audit) as well as non-participants, so that in the absence of the latter, an alternative approach is necessary.

3 Correcting for Sample Selectivity

As described above, the problem being addressed concerns taking information from a non-random subsample – in this case the average energy savings from those who undertook retrofits, which is only available for those households that fully participated in the EGH program by completing both energy audits – and generalizing it to the population as a whole, which in this case refers to the Canadian residential sector. Simply taking average savings for those who fully participated and scaling it up by multiplying by the number of households that did not fully participate ignores the non-randomness of the subsample of full participants, as well as the non-randomness of those who were involved in the EGH program at all, and is unlikely to yield meaningful information. An alternative would be to take average energy savings for all those who participated in the EGH program at all, by completing the first audit, with those who did not undertake the second audit being regarded as having energy savings of zero. This would yield a smaller average value of energy savings, which would then be scaled up by multiplying by the number of households that did not participate at all in the EGH program. However, as described in the previous section, this would ignore the non-randomness of those who participated at all in the EGH program, and again is unlikely to yield meaningful information.

In general, issues arising from non-random sample selection, or sample selectivity, are corrected by taking account of the probability of being included in the non-random sample. Given that participation depends of the characteristics of the households and houses, the probability of being included in the sample also depends on these characteristics. Thus, as detailed in Section 3.1 below, using this method requires information on participants as well as on non-participants in order to compare their characteristics and establish the probability of being included in the program. This is a problem for EGH, as the program only collects information on participants. In view of this difficulty, alternative approaches need to be considered.

3.1 Typical Econometric Approach to the Sample Selectivity Problem

The typical method used to correct for a sample selectivity problem is to assess the probability of participation by use of a probit model, and using the estimated parameters to obtain estimates of the “Inverse Mills ratio” for each participant, which is then included as an extra explanatory variable in the second-stage analysis. This requires having information on both participants and non-participants, as explained below.

First, consider a hypothetical data set including participants and non-participants, and let $y=1$ if the household completed the 1st audit and $y=0$ otherwise. The standard method models the unobserved variable y^* , which is the intensity of desire to undertake the first audit, as a function of income, the state of the house, and possibly other factors. From this probit model, estimated using all observations (i.e., those who did and those who didn't undertake the 1st audit), the estimated parameters are used to determine estimated values for the Inverse Mills Ratio (IMR). Next, just using the subsample of those who undertook the first audit, the variable of interest (e.g., energy consumption) would be modelled and estimated, with the IMR included as an additional explanatory variable, thereby resolving the sample selectivity (SS) problem. The reason this works is that the expected value of the error term conditional on being selected into the first audit is non-zero, so that estimation without the SS term included leads to biased estimates. Essentially, the SS term is (a consistent estimator of) the expected value of the conditional error term, so that including it removes the bias (called SS bias) when OLS is now applied.

Hartman (1988), attempted to evaluate the effectiveness of the residential conservation programs offered by Portland General Electric Company (PGE) for the period 1978-1979. PGE customers faced several decisions, the first one was whether to become involved in the program and undergo a first audit, the second was whether to apply for a no-interest loan, and the last was whether to undertake a conservation investment based on the audit. Therefore, as with the EGH data, the same problem of sample selectivity in the program emerges due to self-selection decision. Hartman makes use of a method similar to the one described above to correct for non-randomness of the sample of participants. Specifically, he models two decisions: participation in

the program (which is highly correlated with applying for a loan) and making a conservation investment. In the first step a probabilistic choice model is used to describe the self-selection decision; the second step includes these probabilities in the relationship between participant characteristics and energy use. Here, modelling the first decision (participation) is possible since the dataset used contains information on both participating and non-participating customers of the utility offering the program.

Hartman found that the correction for self-selection importantly affects the results and that energy savings achieved by this type of program are largely overestimated when selection bias is not taken into consideration. This means that when participants and non-participants are considered to be identical, the results can be greatly misleading. In this particular case, young, high income and highly educated households availed themselves of the program more so than others. The energy savings that can be attributed to the program constitute only 40% to 60% of the total energy savings over the period for these households, and are about one half of the energy savings of average households. It was also found that households who participated in the programs were those who would undertake more conservation investment anyway, making the efficiency of the program questionable. As noted above, a key aspect of this selectivity correction method is that its implementation requires characteristics of both participants and non-participants, information which is not available in the case of the EGH dataset.

Another attempt to evaluate a voluntary environmental program can be found in the study of Arora and Cason (1995), who examine the determinants of the decision to participate in the US Environmental Protection Agency's 33/50 program. They use the Toxic Release Inventory database, wherein every firm is obligated to report its release of chemicals. As part of this database, there is information on participating firms in the 33/50 program. As a result, the sample contains information on both participants and non-participants. Arora and Cason used the DUNS number, a unique identifier assigned by a financial service to each parent company, to match financial information from the Compustat database. The focus here is on participation in the program and its determinants, rather than on any pollution reduction associated with the program. Therefore there is no need to correct for sample selection. They used an iterative maximum likelihood method and found that firms with higher aggregate releases, chemical

firms, firms from less highly concentrated industries (in terms of market structure), and larger firms were more likely to participate in the program.

3.2 Alternative Approaches

Several other studies have considered the question of how to evaluate environmental programs with voluntary participation and the related problem of sample selectivity. A brief review of their approaches is provided in this section.

The treatment of sample selectivity issues can differ according to the nature of the data that are available. For example, in cases where data on non-participants are not included in a particular survey, an alternative approach is to use information from two separate datasets: one covering program participants, and the other one covering a larger (and possibly the entire) population, such as a census. In this case, information on participants can be matched with information from the census dataset in order to build a combined dataset comprising information on both participants and non-participants. However, this works well only if an individual identifier is available for each observation in both datasets in order to match up information correctly. In this case, the characteristics of the two groups (participants and non-participants) can easily be compared, allowing the results of a program to be generalized to non-participants.

This is the essence of the approach considered by Pizer, Morgenstern and Shih (2008), who evaluate two voluntary climate programs in the United States that are aimed primarily at the manufacturing sector. They look at the “Climate Wise” program, launched by the Environmental Protection Agency in 1993, and the U.S. Department of Energy’s 1605(b) program, started in 1994, which is a program of voluntary reporting of greenhouse gas emissions. The voluntary nature of participation in these programs leads to the same difficulty as described above for the EGH program when it comes to generalizing the outcomes to non-participants. However, the data collected as part of these two U.S. programs contains identification variables – such as the name and address of the participating firms – that can be used to match participants with a market-wide database (that also contains identification variables) that includes information on most of the firms in the sector. Therefore, the

combination of the different sources of data provides precise information on which firms participated in the environmental programs and which did not among the census dataset. Following this combination of data sources, it is then easy to proceed with an analysis of the participation decision using methods similar to those described earlier.

In this particular application, the authors are interested in assessing the benefits of the two programs under consideration in terms of greenhouse gas emissions reductions, measured as the difference between the emissions of a firm that enrolled in one of the programs and the emissions of that same firm if it had not enrolled in the program. These emissions are proxied via the use of data on energy (fuel and electricity) expenditures. To control for selectivity issues, two approaches were used. The first approach assumes that program participation depends on both observed and unobservable variables that may be correlated with the outcome. This requires a specification of the participation decision based on at least one ‘excluded’ variable, a variable that influences the participation decision without affecting the outcome (greenhouse gas emissions). This leads to a very similar approach as outlined in Section 3.2. A second approach is based on the assumption that the participation decision can be ignored, conditional on observed covariates. It uses a propensity score-matching strategy, where each participant is matched with a similar non-participant, based on the likelihood of participation.

When no attempt is made to correct for sample selectivity bias, apart from a few exceptions, small and insignificant results are obtained for changes in energy expenditures for program participants between one year prior to enrollment in the program and two years later. With the corrections for selection bias based on the first approach (estimation of the probability of participation, and inclusion of the IMR correction term in the outcome regression), they found almost no difference in energy expenditures between participants and non-participants. With the second approach, the 1605(b) program was found to have a small negative effect on energy expenditures. On aggregate, they found the effect of each program to be no more than 10% and probably less than 5% on electricity expenditures. There is no evidence of any statistically significant effect of either program on fuel costs. Participation in the “Climate Wise” program increases electricity costs slightly, but the effect vanishes after two years of participation in the program. The increase in electricity costs could be explained by the use of emission-saving

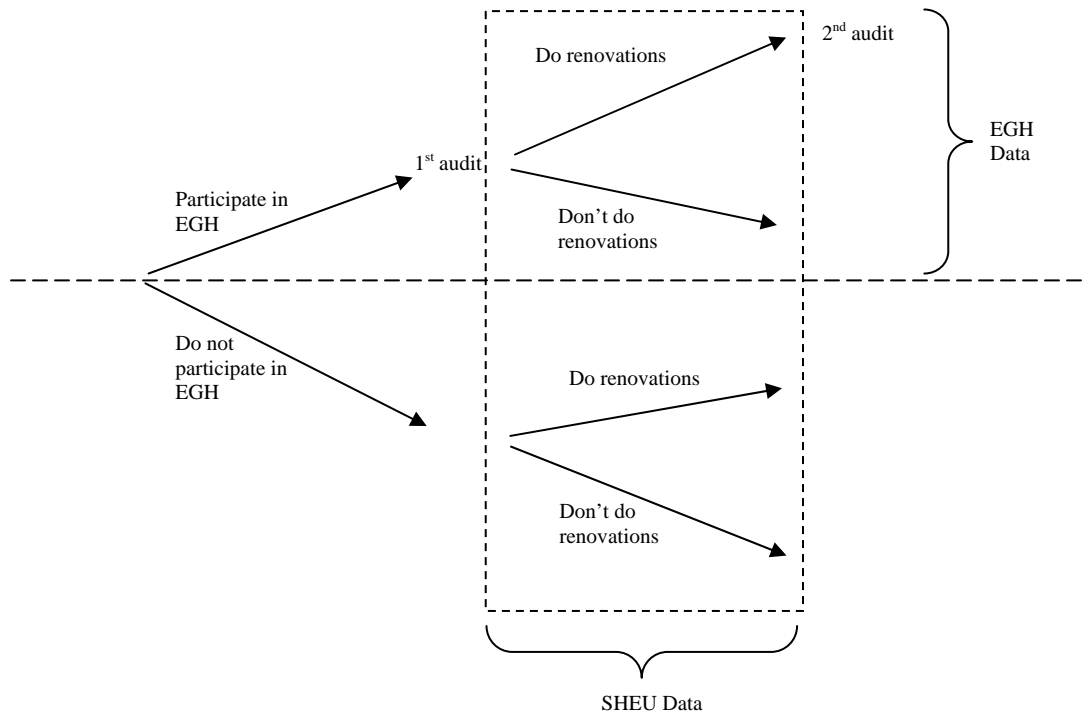
techniques that would increase electricity use, or may be due to plants focusing their emission reduction on aspects than energy use reduction.

When information on non-participants is not directly available, or when no common identification variable is available in both datasets, a matching method resulting in a combined data set of participants and non-participants cannot be used. Thus, a different approach is required, as considered in Section 3.3.

3.3 An Approach to Dealing with Sample Selection in the EGH Data

To help overcome the absence of information on non-participants in the EGH database, the approach considered here makes use of a supplementary dataset, the 2003 Survey of Household Energy Use (SHEU03), which contains information on energy consumption in the Canadian residential sector. SHEU03 surveyed a number of randomly selected Canadian households, and includes information regarding retrofits made by survey respondents. This survey is national in scope, with weights applied to each of the observations in order to facilitate aggregation to the entire residential sector. Therefore, SHEU03 can be viewed as a database that pertains to the entire Canadian residential sector, thus including both participants and non-participants in the EGH program. Although SHEU03 includes questions regarding retrofits, there is no information on whether participants who undertook renovations did so as part of the EGH program. This means that households included in SHEU03 who renovated their house, may or may not have done so as participants in the EGH program. Similarly, households included in the SHEU03 dataset who did not renovate their house may or may not have been included in the EGH program for the first audit. Figure 1 provides an overview of the decision tree faced by each household, and how it relates to the information available in each survey.

Figure 1: Household Decision Tree Relating EGH and SHEU03



Although SHEU03 covers participants and non-participants in the EGH program, unlike the examples outlined above where precise matching of individuals was possible, there is no individual identifier that can be used to match up households across the SHEU03 and EGH datasets. As a result, it is not possible to identify which of the SHEU03 households participated in the EGH program. .

Swan *et al.* (2008) build a database representative of the Canadian housing market using both EGH and SHEU data, using a different method to match the data. They choose to utilize the EGH to obtain information on a variety of residential housing equipment characteristics and energy consumption features, not available in other surveys; and they use the SHEU data to illustrate the Canadian housing market. A number of EGH cases are selected according to several “statistically representative descriptive parameters of the Canadian housing market” so that the selection reflects the SHEU distribution. Specific cases are selected according to province, type of house, age of house, number of storeys, floor area, domestic hot water energy source and heating energy source. A weight is attributed to each case, so that the full sample will

be representative of the Canadian housing market. The result is a set of nearly 17,000 observations, each with a weight of approximately 525, which is claimed to statistically represent the Canadian housing market. The detailed information on house construction and energy characteristics of each observation can be used in estimating the effects of new technologies or upgrades. Since the distribution of the observations of the new sample reflects the distribution of the SHEU, the sample is considered unbiased, with no selectivity problem.

Although the purpose of Swan (2008) is not the same as ours, the selection method provides an interesting avenue for matching EGH data and SHEU data and is used in Section 5, in order to estimate the potential of the EGH program for residential energy savings in Canada.

Before turning to the issue of matching information from the two datasets, and assessing whether information that would help with the sample selectivity problem can be obtained in this way, it is necessary to explicitly consider the information that is contained in the two datasets and determine whether, matching problem aside, it is likely that the use of the two datasets may help in dealing with the sample selection problems that have been identified.

4 Factors influencing participation and retrofit decisions

We start with a general comparison of the most relevant major components of the EGH and the SHEU datasets. First, for a number of characteristics the sample population of the EGH data is compared to that of SHEU. In other words, the average characteristics of EGH participants are compared to the average for the Canadian population. Second, information regarding the decision to undertake renovations is present in both datasets. The characteristics of households who renovate or improve their homes are examined across both datasets in order to see whether households who decide to renovate or improve their home within the EGH program differ in any systematic ways from those who do so at the national level (SHEU) and, if so, in what respects.

Unfortunately, there are almost no variables pertaining to the characteristics of the household in the EGH dataset whose values could be compared to corresponding values for households in SHEU03. In particular, the EGH dataset focuses on technical information related to the house, omitting any information on the household. This is detrimental for the analysis being considered here, since the decision to participate in the EGH program depends on both the characteristics of the house *and* the household. To overcome this issue, use is made of the first three digits of the postal code, known as the forward sortation area (FSA). Specifically, average values of relevant demographic and socio-economic variables (such as income, education, employment) obtained from Canadian census data for each FSA are appended to each observation in the EGH dataset by matching according to the FSA information for each observation.

To better align the two datasets, observations for houses built before 1900 are removed from the EGH sample since they are absent from SHEU03. In terms of the type of dwelling, the few observations for apartments, duplexes and mobile homes included in the EGH dataset are removed, as they are not eligible for a grant under the EGH program. To facilitate comparisons, observations for these same categories are also removed from the SHEU dataset. In EGH, the categories of “Row”, “Row house, middle unit” and “Row house, end unit” are all contained in the single “Row houses” category in SHEU03. In EGH, the decision to undertake retrofits is represented by whether a second audit is undertaken. In SHEU03, the decision to renovate the house is captured in the responses to questions concerning whether “the household made one or

more improvement to the house in 2003” and whether “the household is planning to make one or more improvements to the house in 2004”.

Based on these revised data sets, the roles of house and household characteristics on the decision to participate in the program and further, to renovate, improve or make retrofits to the house are examined. The EGH sample is expected to be biased compared to the SHEU03 data. Some aspects of this bias can be seen by comparing the characteristics of EGH participants with the characteristics of the entire population, reflected in SHEU03.

Both datasets contain some households that undertook renovations and others that did not. Of course, the renovation decision in EGH does not reflect the Canadian trend, because of the biased sample, and the renovation decision in the SHEU03 does not necessarily reflect participation in the EGH program, as some households may have undertaken renovations outside this program. Still, analyzing the decision to undertake renovations in each dataset might provide some insight into common determinants of the renovation decision, and therefore what is the potential for greenhouse gas emissions reduction due to home improvements.

In view of the objectives of the EGH program it would be expected that households in the EGH dataset would be more likely to decide to renovate than would be the case for households in the SHEU03 dataset. A comparison of participation rates in the two datasets appears to support this hypothesis. In the EGH data, close to 19% of households who participated in the program made some retrofits. In the SHEU dataset, only 15.3 % of the households made one or more improvements to their house in 2003, and near 17% were planning to do so in 2004. However, in both datasets, this proportion varies noticeably across provinces.

The following analysis presents the main findings for the variables examined and, where relevant, the main differences across datasets. To examine the decision to participate in the EGH program, we examine the differences in the distributions for the EGH and SHEU samples for a given variable. A characteristic is considered to be over-represented in the EGH sample when buildings with this feature are more likely to participate in the EGH than others, with the EGH sample exhibiting this feature more often than the Canadian average as reflected in SHEU03.

Conversely, a characteristic is considered to be under-represented if buildings with this feature have a lower probability of participating in the EGH program. Detailed tables associated with each variable, on which the following summaries re based, are contained in Appendix A.

When looking at the decision to renovate, we consider the rate of renovation of each sub-group (e.g., province, or year of house construction, etc.) for a given variable. The comparison of this rate between the EGH sample and the SHEU03 sample, measured as the percentage of households within a category that undertook a renovation, retrofit or at least one improvement in their house, tells if a building with a particular feature has a higher chance of being renovated under the EGH program than the Canadian average. .

4.1 Province

Western Canada (British Columbia plus the Prairies) is over represented in the EGH sample and the remaining regions are under-represented. Quebec constitutes only 12.2% of the EGH sample while it accounts for more than 20% of Canadian households. Ontario is slightly under represented, comprising 32.8% of the EGH against 39.7 % of Canadian households. Conversely, Alberta and Manitoba represent 20% and 8.1% respectively of the EGH participants against 11% and 3.9% of Canadian households respectively. Therefore, province of origin seems to greatly influence participation in thee EGH program. The program is more popular in western Canada than in the highly populated provinces of Quebec and Ontario.

As for the renovations, in Quebec, Newfoundland and Prince Edward Island, less than 10% of participants undertook a second audit (PEI 6.9%); while in the Prairies, around 25% of the participants did so (Saskatchewan 27.5%). For BC, Ontario and New Brunswick, approximately 18% of EGH participants undertook a second audit, which corresponds to the program average. Within SHEU03 renovations and retrofits are distributed more evenly across provinces, ranging from 11.1% in Quebec to 19.4% in Ontario. Generally, the highest rate of renovations observed in SHEU03 is found in the Atlantic Provinces, while the lowest rates occur in Western Canada. Similar observations apply to the stated intention to renovate in 2004. Interestingly, Alberta, which has one of the highest rates of retrofit among EGH program participants, has one of the

lowest rates of renovation (11.2%) when the entire population is considered. Similarly, PEI, which has a very low rate of renovation among EGH participants, has the second highest rate of renovation (19.4%) when the entire province is considered (in SHEU03). A possible explanation is that the EGH program is more popular in Alberta so that households planning to improve their home would first enroll in the program, while in the Atlantic Provinces the program may not be as well advertised or may not be considered appropriate given the renovation needs in this region. This would also explain the over-representation of Alberta in the EGH sample. However, the results need to be interpreted with care since households in the Atlantic Provinces account only for a very small portion of the EGH sample.

4.2 Year of construction

In the SHEU dataset, a high proportion of buildings were constructed between 1970 and 1990 (19.6%), and between 1980 and 1990 (18.2%). In EGH, buildings dating from between 1970 and 1980 are also the most important group of participants, but here they represent almost 25% of the EGH sample. Overall, buildings constructed before 1980 are over-represented in the EGH sample, as compared to the SHEU sample. Owners of buildings built after 1980 participated less in the EGH program and are under-represented in the sample, as compared to SHEU. This suggests that the age of a building influences the decision to participate in EGH, and that older buildings have a higher chance of being included in the EGH sample.

Among EGH participants, 20% of the buildings built before 1960 received retrofits. This rate is slightly higher for buildings built during the two next decades (22%), and then decreases for more recent buildings. For buildings constructed since 1996, the renovation rate for EGH participants drops to 5%. This pattern generally matches the composition of the EGH participants: with more buildings within particular age groups enrolled in the program, there is a greater chance that buildings in this age category will undergo renovations. As for the Canadian residential sector as a whole, reflected in SHEU03, the trend is slightly different, with the rate of renovation decreasing steadily as the age of the building decreases. That is, there are fewer renovations for houses that were constructed more recently. In SHEU03, this rate never exceeds 22.7%, which is the rate for the buildings constructed before 1946. Overall these findings

indicate that the age of the building does have a small effect on the decision to renovate, but this effect is quite similar for both EGH participants and Canadian households generally. Therefore, to be included in the EGH program does not bias how buildings are renovated according to their age.

4.3 House type

In the SHEU data, single detached houses represent 84.7% of the sample, but they represent 92.8% of the EGH sample. The remainder of the two samples comprises row houses (and double houses for the SHEU). The distribution of both datasets according to the type of the house varies, but the trend of an extremely high portion of single detached houses in the sample is common to both the Canadian population and EGH participants.

Within the EGH program, the decision to renovate does not seem to be influenced by the house type, with both exhibiting a rate of renovation around 19%. The result is the same for the SHEU03 data, with both single-detached houses and row houses having a similar renovation rate in 2003 of 15%. As for the intention to improve the house in 2004, single detached houses have a higher rate of intention (17%) than do row houses (11%).

4.4 Storeys

Close to 50% of the houses have one storey, in both the SHEU and the EGH samples. However, houses with one and a half storey constitute 10% of the Canadian housing market but only 3.5% of the EGH sample. Two storey houses make up most of the remaining half of the EGH sample (42.2%) but only one third of Canadian houses. Therefore, the number of storeys does not appear to affect participation in EGH, except for the two storeys houses which are more likely to become EGH participants.

Among EGH participants, renovations occurred more often in houses with one or one and a half storeys (20%) than in houses with more storeys. The smallest rate of renovation (15.5%) is attributed to houses with three storeys. This diverges from Canadian rates observed in SHEU03

however, since only 13.3% of the houses with one storey had an improvement in 2003, while 21.1% of the houses with one and a half storey did so. There is also a difference for houses with two and a half storeys, where 18.5% of the EGH participants had a renovation compared to 22.4% for the SHEU data, although this housing category represents only a very small share of the Canadian housing market and of EGH participants. Overall, it appears that the number of storeys influences the decision to renovate the house, since houses with different numbers of storeys have different renovation rates. But this effect is different for EGH participant and non-participants since renovations rates by number of storeys differ between the two datasets.

4.5 Furnace fuel source

As shown in Table 1, the source of furnace fuel used by almost three quarters of the population is natural gas, in both the SHEU and the EGH datasets. Households using electricity as a source of furnace fuel are over-represented in the EGH sample, 14.9% against 4.1% for the overall population. Oil is the second most important source of furnace fuel in the Canadian population (13.4% of households), but households using oil are not an important group within the EGH sample (10.6). Participation in the EGH program seems to matter more for electricity users than for the rest of the population.

The furnace fuel source appears to importantly affect the decision to renovate a house. Among EGH participants, there are wide disparities among the rates of house renovation depending on the fuel used for the furnace. Some 21.4% of houses using natural gas undertook renovations compared to 17.4% of houses using oil and less than 10% of houses using electricity. In terms of other furnace fuel sources, 12.4% of the EGH households using propane renovated their houses while around 10% of these who used various types of wood did so. Renovation rates according to fuel type also vary in the SHEU03 data, although the highest rate of home improvement occurs for households using propane (35% against 16% on average) even though there are a limited number of houses using this fuel source for heating in Canada. The next highest rates are observed for households using wood and oil (around 20%), while almost 15% of households using natural gas improved their house. Renovation rates according to furnace fuel source based on the question concerning intentions to improve the house in 2004 are similar.

Table 1: Comparison of renovation rates by furnace fuel source

Furnace Fuel Source	EGH sample		SHEU sample	
	% who did renovation	% of sample using that source of fuel	% who did renovation	% of sample using that source of fuel
Natural gas	21.4%	73.6%	14.8%	74.4%
Oil	17.4%	10.6%	20.8%	13.4%
Electricity	8.5%	14.9%	7.3%	4.1%
Propane	12.4%	0.6%	34.9%	1.1%
Wood	7%	0.4%	21%	6.2%
All*	19%	100%	15.9%	100%

*Note: Results might differ from 100% in the “% of sample” columns, due to non-responses which are not reported here.

4.6 Size of the house

The size of the house is measured by its footprint (sum of the floor areas in meters squared) in EGH. The average house size for EGH participants is 92.564 meter squared, with a standard deviation of 33.459. Houses being renovated are on average 92.4 meters squared and houses which not renovated have an average size of 92.6 meter squared. The relation between the size of the house and the retrofit decision is presented in Figure 2 for EGH participants and Figure 3 for the SHEU03 data. The left hand part of Figure 2 (and 3) shows the house size distribution for EGH participants who did not renovate their house while the right-hand side shows the distribution for participants who did renovate their house. No major difference appears, indicating that the decision to renovate does not depend greatly on the size of the house.

In SHEU03, where the size of the house is captured by the total heated area, given in square feet, the same trend appears. The average floor area of the sample is 1544.15 square feet (143.5 square metres). The average size for houses which were improved in 2003 is 1542.63 square feet (143.3 square metres) and the average size for the others is 1544.43 square feet (143.5 square metres). According to Figure 3, the distribution of house size is similar for households who improved their house in 2003 and households who did not. Overall it appears that this variable does not affect the decision to renovate the house in either dataset. It also does not appear to affect the likelihood of being in the EGH sample. As the way in which house area is measured

differs across the two surveys, it is not possible to make meaningful comparisons of average sizes between the SHEU and EGH datasets.

Figure 2: Footprint area of the house and renovation rate in EGH

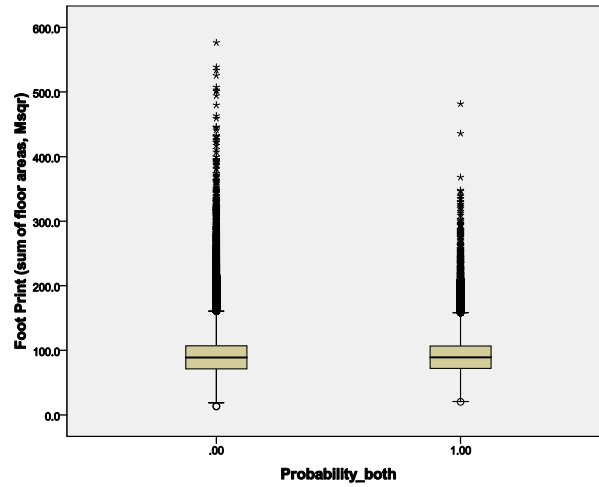
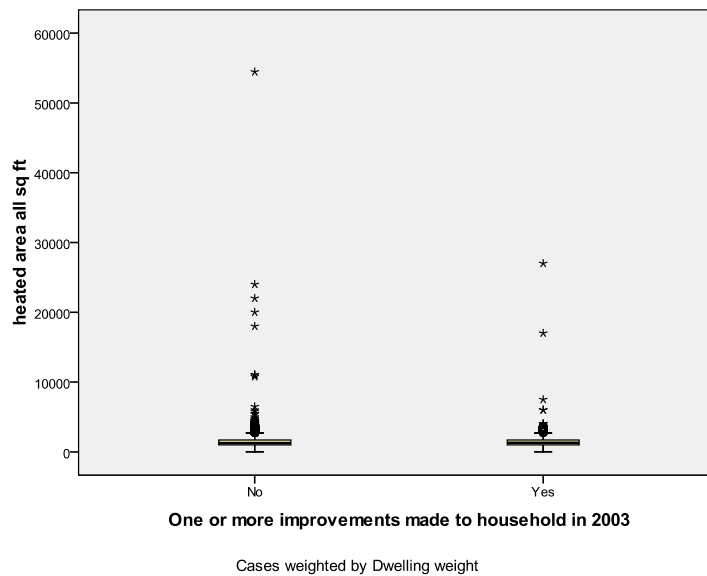


Figure 3: Heated area of the house and renovation rate in SHEU03



4.7 Other house characteristics

In terms of the number of occupants, total fuel consumption, energy intensity before retrofits, and average house price, there are some differences between households who do and who do not undertake renovations, in both the EGH data (Table 2) and the SHEU data (Table 3). However, due to differences in the definition of the variables across the two surveys, it is often difficult to compare these values. Some observations, though, can be made. Specifically, in EGH, houses in which renovations are undertaken exhibit higher fuel consumption and hence fuel costs, and higher initial energy intensity. They also tend to be located in areas where the average house price is slightly higher, and they have a slightly lower number of occupants. There is no information on house price or on fuel expenditure in SHEU03. The average household size is higher in the EGH sample than in the SHEU03 sample, both for households undertaking renovations and for those not doing so. In contrast to EGH participants, the average energy intensity and energy consumption in the SHEU03 is higher for households that did not do renovations. Of course, this may reflect the fact that the values of the EGH variables are pre-renovation, while those for SHEU03 are post renovation. Overall, the distributions of these variables are fairly similar for houses which undertook renovations and those which did not, in both datasets. This might suggest that the decision to renovate is not particularly influenced by participation in the EGH program and that the participation decision may not be affected by these variables. However, the evidence on these issues is not conclusive.

Table 2: Descriptive of quantitative house characteristics in EGH

		No Retrofits	Retrofits	
Total Number of Occupants	Mean	3.42	3.33	
	95% Confidence Interval for Mean	Lower Bound	3.41	3.32
		Upper Bound	3.43	3.35
	Std. Deviation	1.118	1.122	
EGH Fuel Cost - Total (\$)	Mean	2931.4267	3023.2153	
	95% Confidence Interval for Mean	Lower Bound	2925.3265	3011.2556
		Upper Bound	2937.5269	3035.1750
	Std. Deviation	1128.61614	1070.78239	

initial energy intensity	Mean		1024.3074	1132.9895
	95% Confidence Interval for Mean	Lower Bound	1022.0832	1128.4798
		Upper Bound	1026.5316	1137.4991
	Std. Deviation		411.50534	403.76175
Average House Price	Mean		172368.20	171903.88
	95% Confidence Interval for Mean	Lower Bound	171881.53	170952.00
		Upper Bound	172854.88	172855.75
	Std. Deviation		90040.939	85224.321
EGH Fuel Consumption - Total (MJ)	Mean		213285.939	231664.410
	95% Confidence Interval for Mean	Lower Bound	212834.881	230775.983
		Upper Bound	213736.997	232552.836
	Std. Deviation		83451.6434	79543.3037

Table 3: Descriptive of quantitative house characteristics in SHEU

One or more improvements made to household in 2003			No	Yes
Household Size	No	Mean	2.88	2.80
		95% Confidence Interval for Lower Bound	2.88	2.79
		Mean	Upper Bound	2.88
		Std. Deviation	1.418	1.300
effsqft	No	Mean	.1041	.0992
		95% Confidence Interval for Lower Bound	.1040	.0990
		Mean	Upper Bound	.1042
		Std. Deviation	.12586	.12167
total GJ energy all sources	No	Mean	135.5551	126.5288
		95% Confidence Interval for Lower Bound	135.4939	126.4176
		Mean	Upper Bound	135.6163
		Std. Deviation	79.47836	60.93146

4.8 Income

The income, reported from the census FSA data where a house is located, is clearly a variable that affects participation in the EGH program. The sample of EGH participants is biased toward high-income households. Households with an annual income below \$40,000 represent 31% of the Canadian population, but only 3.8% of EGH participants. Households with incomes category above 40 000 are all over-represented. One half of EGH participants have incomes in the \$40,000 to \$60,000 range, against 23% for the overall population. About 30% of the EGH have incomes between \$60,000 and \$80,000, against 16% of the Canadian population.

In the EGH data, income is associated with renovation rates. Households at the extremes of the income range have the lowest rates of renovation, 15.7% for households whose income ranges between \$20,000 and \$40,000 and 17% for households with incomes of more than \$80,000. Households with income between \$40,000 and \$80,000 form the largest group among EGH participants, and renovated their houses at a rate above 19%. A similar pattern is observed for the SHEU03 data. Households who have the lowest and the highest incomes have a renovation rate slightly lower than the average (14% and 15.3 %, respectively) while households whose income is in the middle range have slightly higher renovation rate (17.2%). The decision to renovate is therefore influenced by income, but the effect appears similar among EGH participants and the residential sector as a whole. Although income does seem to have some influence on the decision to renovate, it appears to have an even greater influence on the type of renovation and the amount spent on improving the house. This is an important factor in retrofit behavior, but here the focus is on the decision to retrofit rather than the type(s) of retrofit that are made.

As for other household characteristics, the unemployment rate in the FSA where the house is located does not seem to affect the decision to renovate in the EHG dataset, as rates for participants are comparable whether they renovated their house (5%) or not (5.4%). In the same way, FSA education levels are similar for households that did renovations and those that did not. There is no information on the unemployment rate or education levels in SHEU03.

4.9 Conclusion

Overall, the criteria that seem to have the largest influence on participation in the EGH program are the location, the year of construction of the building, the fuel type used for furnace and the income of the household. It seems that the program is more popular in western Canada than other provinces; buildings that are older also have a greater likelihood of being included in the EGH sample than others, as do two-storey houses. The use of electricity as a source of fuel for the furnace increases participation in the EGH program. Income is clearly a variable that affects participation in the EGH program, since the sample of EGH participants is biased toward high-income households. Otherwise the type of the house was not found to affect participation in EGH, while the size of the house as measured by the floor area probably does not matter.

When comparing the determinants of the decision to renovate in the EGH and SHEU datasets, it appears that this decision is also affected by the participation in the EGH. First, participation in the EGH program leads to higher average rates of renovation, 19% against 15%. Secondly, when the rates of renovation are ranked according to specific variables, the following findings are of interest. Provinces that have high rates of renovation at the Canadian level are not those that have high rates of renovation among EGH participants. Conversely, provinces with average or low levels of renovation at the Canadian level may have high rates of renovation among EGH participants. In these provinces, households willing to renovate will probably first enroll in the program, perhaps due to better advertising of the program, while in other provinces, households willing to renovate tend to ignore the program. The number of storeys influence the decision to renovate the house, since houses with different numbers of storeys have different renovation rates. Here, renovation rates according to the number of storeys vary between EGH participants and the Canadian average.

The age and the type of the house each have effects on the decision to renovate. However, being an EGH participant does not seem to change that effect. The same result applies to income. Although it does seem to have some influence on the decision to renovate, the effect appears similar among EGH participants and the residential sector as a whole. Income likely has a substantial influence on the type of renovation and the amount spent on improving the house.

Finally, the size of the house measured by its floor area or foot print does not affect the decision to renovate the house in either dataset.

Factors such as income, the unemployment rate and education levels must be analyzed with care, since for the EGH dataset these are not collected directly but they represent average values for the FSA where the house is located.

4.10 Why households don't renovate: evidence from SHEU03

In SHEU03, households that did not make any improvements to their house were asked about their reasons for not doing so. Two thirds of these households indicated that they did not make improvements to their houses because no improvements were necessary. Of the remaining households, 17.1% stated that the improvements were too costly, while 1% stated that they were not aware of government financial aid or assistance and 0.6% indicated that there was no government financial aid or assistance. The appropriate interpretation of responses concerning the potential for government programs to increase energy saving retrofits through the development of financial support is ambiguous. Fewer than 2% of these households state the absence of government financial support as a reason for not improving their houses, but still almost one household out of five did not do renovations because of the high costs – costs that government programs are expected to alleviate. This would suggest that households do not consider government financial support as a sufficient inducement to undertake retrofits. These answers from SHEU03 respondents could also mean that the particular retrofits eligible for a grant under programs such as EGH are not the ones that households want to undertake. However, this conclusion would apply only if the statement that “improvement is too costly” means too costly relative to the household’s financial constraints. If “too costly” means too expensive relative to the energy savings expected, then the potential for government programs would be limited, in this case due to technical constraints.

Looking more closely at the responses by household location helps to illustrate the differences in retrofit behavior observed across provinces. Manitoba and Saskatchewan have the highest share of households that did not make improvements to their houses due to cost considerations (36% and 33% respectively). These provinces also have the highest share of households that were not

aware of government financial support, although the share remains very low at 2.6% and 3%, respectively. Otherwise, no major provincial factors stand out. In Alberta, British Columbia and Quebec, which had the lowest rate of renovation in Canada, the response that no improvements were necessary was provided in 69% (68% for Quebec) of the cases. In Prince Edward Island, which had one of the highest renovation rates in Canada, but one of the lowest among EGH participants, no households identified the absence of government programs as a reason for not improving their houses.

5 An attempt to assess the potential of the EGH program

From what has been seen above, there is no obvious way to fully solve the sample selectivity problem in order to properly assess the potential of the EGH program. Some characteristics that influence participation in the program and the decision to do renovations have been found, but the precise effect of these variables is not known. Below we discuss an approach that may at least partially overcome the problem of sample selectivity bias in an evaluation of the potential of the EGH program in Canada, and we present two scenarios based on this approach.

5.1 Method

One way to address the sample selectivity problem is to study specific groups within the population. The idea is to divide both the EGH and SHEU dataset into subgroups according to variables that are available in both datasets, as in Swan *et al.* (2008). It is hoped that by examining groups with relatively similar characteristics, we will be able to obtain a better picture of the participation and renovation features of each group. This solution is expected to limit the effect of the sample selectivity problem. For example, if for some groups, there are no observations from the EGH sample but there are observations from the SHEU sample, it means that no households with these particular characteristics participated to the EGH program. This will not solve the selectivity problem since in each subgroup of the SHEU there is still a possibility that some households participated in EGH and some did not; and there is no way to know which households belong to each group. Another limitation of this method is that when more subgroups are created to obtain more precise results, the number of observations in each group that is formed is reduced. Here we limit ourselves to dividing the sample according to the variables that most influence the decision to participate in the EGH program. Based on the analysis provided in Section 4, the most important variables were found to be location (province), the vintage of the house, and the income range of the household.

Following this approach we arrive at a division of 10 provinces, 6 periods of building construction (1900 to 1945, 1946 to 1960, 1961 to 1970, 1971 to 1980, 1981 to 1990, after 1991)

and 5 income ranges (\$20,000 to \$40,000, \$40,001 to \$60,000, \$60,001 to \$80,000, \$80,001 to \$100,000, and more than \$100,000); so that each dataset is divided into 300 groups. Note that there are no households with an income of less than 20 thousands dollars in the EGH program. For each group within each dataset, the number of observations and the average probability of doing a second audit or of improving the house are reported. The average energy saving achieved after doing a second audit, for the EGH dataset, is also used. These variables allow us to approximate the rate of participation in the EGH program for each group within the population. This is calculated using the ratio of the number of observations in the EGH group to the number of observations in the SHEU group with the same characteristics (province, age of building, and household income).

In some cases, income is not available; and the observation is removed from the sample. In other cases, there are no corresponding observations in the EGH sample, which leads to a participation rate of 0. This is most likely to occur in the Atlantic Provinces and for the highest category of income. It also sometimes happens that there are observations for a group in the EGH but none in the corresponding SHEU group. In such cases the observations for the group in the EGH are removed. Finally, three participation rates are unnaturally high, between 60% and 100% when all other rates lie between 0% and 35%. These high rates are not considered representative and are also removed.

Graphs B1 to B6 in Appendix B show the participation rates for each category of buildings. Findings are consistent with those reported previously: the Prairies have generally higher rates of participation in the EGH program, as well as households whose income ranges from \$40,000 to \$60,000 or from \$60,000 to \$80,000. Again, owners of houses built in earlier years participate more in the EGH than owners of recently built houses.

For each group, the rate of renovation is determined using the probability of doing a second audit for the EGH data and the presence of one or more improvements to the house in 2003 for the SHEU data. Graphs C1 to C6 in Appendix C show the renovation rates of the EGH groups. As seen earlier, the houses located in the Prairies and the houses which were built between 1946 and 1980 are more likely to undergo renovations and a second audit. The renovation rates according

to the income range of the household do not vary substantially. For the same location and the same age of the house, renovation rates are similar, whatever the income of the household. Income does not seem to have a great effect on the rate of renovation among EGH participants.

Finally, graphs D1 to D6 in Appendix D show the average energy savings per case for each group of buildings. Energy savings decrease steadily for renovations in more recently constructed houses. Quebec and Ontario have generally lower energy savings, and there is no clear trend in terms of the relationship between income and energy savings. Energy savings across different income ranges vary across location and house age. The Atlantic regions have many categories with no energy savings, as they have many categories for which there has been no EGH participation and therefore no renovations.

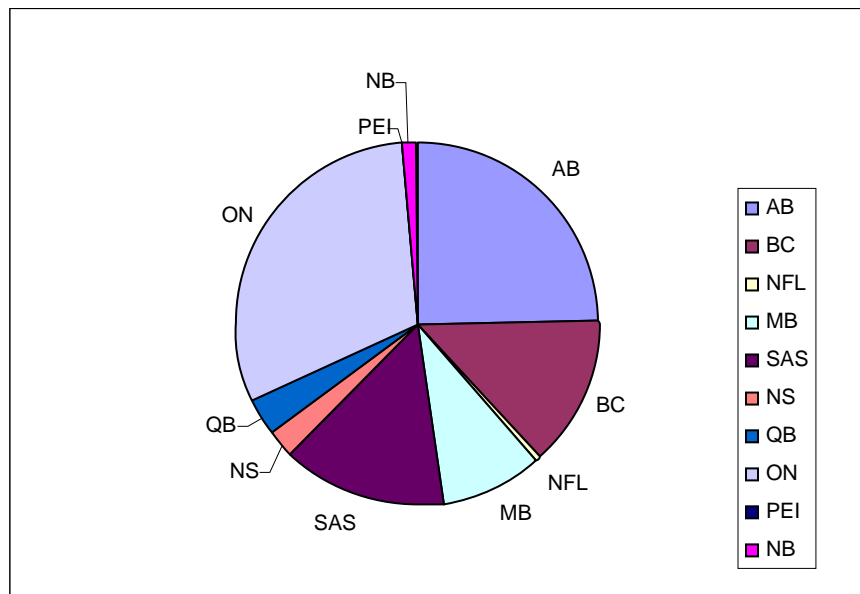
5.2 Scenario 1: a uniform increase in participation

There are several ways to assess the potential of the EGH program. Currently the number of EGH participants represents less than 2% of the overall Canadian housing stock. Given the self-selection associated with this voluntary program, some households will never become involved in the EGH program. Considering a scenario where entire Canadian population would participate in the program as a basis for calculating the potential for energy savings from the program therefore does not make sense. Still, given the low participation rates, it is reasonable to assume that there is potential to expand the EGH program in Canada and obtain energy savings. These energy savings will depend on the number of EGH participants, the share of EGH participants who undertake retrofits and the average energy saving per case. Therefore increasing energy saving in Canada through the development of the EGH program can be achieved by increasing one or more of these three variables. It is difficult to increase the amount of energy saved per case, since this depends mostly on the technical characteristics of the house. However, the proportion of participants undertaking retrofits and the number of participants can be influenced by developments of the program aimed at encouraging such behaviour.

The potential for increasing the number of EGH participants within each category of house is captured through adjusting the rate of participation (number of participants compared to the

entire population in each category). The rate of renovation is captured through the proportion of EGH participants who undergo a second audit. An increase in the participation rate or an increase of the renovation rate among EGH participants by the same amount will have exactly the same effect since what matters for the energy savings is the number of households who do renovations. For example, an increase of 10% in the number of EGH participants or an increase by 10% in the renovation rate simply increases by 10% the total energy savings realized by the EGH program. Table 6, in Appendix E, provides details of the total amount of energy saved by province and by house vintage, in megajoules, before and after an increase of 10%. The EGH has led to a saving of 1946 terajoules of energy so far in Canada, calculated as the average of each group multiplied by the number of participants in each group. An increase of 10% in the participation rate or of the renovation rate, would increase energy savings to 2140.5 terajoules of energy. This would involve a total of 16,554 additional EGH participants in Canada and a total of 194.5 additional terajoules of energy saving. Figure 4 gives the repartition of the total energy saved by province. This outcome is not affected by a uniform increase of 10% in energy savings.

Figure 4: Repartition of total energy saving by province



British Columbia and the Prairies provide a large share of energy savings due to their high energy saving per case and their high participation rates. Ontario offers lower energy savings per

case and lower participation rates, but its heavy population weight makes it one of the provinces where most of the energy saving in Canada occurs in this scenario.

5.3 Scenario 2: targeted increases in participation

The choice of an arbitrary across-the-board increase, as explored in Scenario 1, involves an assumption that each group has the same potential for increase. However, there are probably some groups that have a high potential for increased participation and some groups for which it would be difficult to increase the number of participants. In order to get a more realistic picture of the potential for the EGH program, it is important to take into account what is feasible within each group. In this scenario, the efforts to develop the program and to increase its number of participants are targeted to certain types of buildings and owners. Again, due to the lack of household information in the EGH dataset, there is no ideal way to assess where it is feasible to increase the number of EGH participants and where it is not. There are, however, some rather obvious trends that can offer us some guidance.

Trying to increase the participation of certain types of buildings based on their age does not seem a good way to achieve results. Indeed, if recent buildings have participated less in the EGH program, this is probably because renovations in these buildings are not expected to generate significant energy savings. Efforts to develop EGH program participation among these buildings, which are not generally in need of renovations, are unlikely to yield much in the way of rewards. The same reasoning applies to selecting buildings according to the income range of their owner. If households with incomes between \$ 20,000 and \$40,000 do not tend to become involved in the EGH program, it is likely because calling for an audit is costly, and so is doing the retrofits. Although the program provides a grant, the grant arrives after the expenses have been incurred. Simply increasing the development of the program as it is will not help to relieve the financial constraints faced by these households. So, there is probably not a large potential for increasing participation of groups based on their income. However, the wide disparities across provinces might lead one to think that there could be a serious potential for expansion of the EGH program in regions where participation and renovation rates are relatively low. There is no

reason why these provinces could not achieve levels of participation comparable to those observed in others provinces.

An approach based on encouraging participation in under-represented regions forms the basis of our second scenario of the potential for energy savings from the EGH program. For each category of buildings, the participation rates for a province are compared with the Canadian average participation rate for that category, as shown in Table 4. A realistic objective for the EGH program might be to bring the participation rates of all provinces to at least at the level of the current Canadian average. Therefore, a potential increase is considered for each province that has a participation rate below the Canadian average. For these provinces, the current participation rate is replaced by the Canadian average participation rate. This new participation rate is applied to the population of the group, reflected by SHEU, to obtain the hypothetical number of households that would become involved in EGH. The average energy savings per case of that group are applied in the calculation of the new energy savings.

Table 4: Average Canadian participation rate to EGH by category of buildings

	20-40 K	40-60 K	60-80 K	80 -100 K	100 K +
1900-1945	1.45%	12.98%	4.16%	1.05%	0.89%
1946-1960	2.40%	13.72%	6.14%	1.54%	0.87%
1961-1970	0.63%	14.10%	7.51%	4.77%	1.24%
1971-1980	0.84%	9.88%	7.43%	2.67%	0.71%
1981-1990	0.45%	7.28%	6.00%	2.14%	1.57%
1991 and after	0.25%	5.38%	2.19%	1.51%	0.77%

In addition, the rate of renovation is also taken into account in considering the potential for *energy saving* increases for each category in each province. Indeed, the potential success of the EGH is also influenced by the rate of renovation of each group, as compared to the rates of renovation for the entire population. If the rate of renovation is equal in both the EGH and the SHEU datasets, this means that participating in EGH does not increase the chances of the household undertaking energy saving retrofits. Therefore, increasing participation in the EGH will not increase the number of retrofits done in this province, so that in this case the potential for EGH expansion is limited. In another situation, if the share of households undertaking

renovation is higher among the entire population than among the EGH participants, the potential for EGH is again limited; the households that would enroll in the program are probably these who would have done renovations to their house anyway. Therefore, the development of the EGH program does not lead to additional energy saving. Finally, if the renovation rate is higher among EGH participants than among the population, the EGH program has some potential. This means that participating in the program encourages households to undertake retrofits more often than without the program. Some energy saving will be realized with an increase in the participation rate of this group. To account for this phenomenon, the rates of renovation of both datasets are compared. If the ratio of the rate of renovation in SHEU to the rate of renovation in EGH is below 1, this means that increasing the participation rate will likely increase the number of retrofits done by this group.

Therefore, the potential is calculated for groups that meet two conditions: having a participation rate that is below the Canadian average of that group and having a renovation rate higher than in the total population. Table 5 shows for each category of building the provinces that meet the two conditions, as well as the Canadian average participation rate that is applied to estimate the potential.

For each category, the following calculation is applied to the provinces that appear in Table 5. The rate of participation is replaced by the Canadian average rate of participation. This rate is applied to the population of each group in order to obtain the new number of EGH participants. This number is reduced by the current number of EGH participants in order to obtain the number of additional participants. The average energy saving per case is multiplied by the additional number of participants, which provides the total increase in energy saving for the group. The sum of the number of new participants of each group gives a total of 39,501 new participants in EGH in Canada, for a total of an additional 433.4 terajoules of energy saved. Details regarding the new participants and additional energy saving per provinces are depicted in figures 5 and 6. The results associated with each province are presented in the Table 7 in Appendix D.

Table 5: provinces eligible for a potential increase in EGH participation

	20-40 K		40-60 K		60-80 K		80 -100 K		100 K +	
1900-1945	1.45%	QB, ON, NB	12.98%	NS, NB	4.16%	SAS, NB	1.05%		0.89%	AB, QB
1946-1960	2.40%	BC, SAS, ON, NB	13.72%	AB, BC, ON	6.14%	BC, QB, NFL	1.54%	SAS	0.87%	AB
1961-1970	0.63%	AB, BC, QB, ON, NS	14.10%	AB, BC, NFL, NB	7.51%	NS	4.77%	BC, MB, SAS, QB	1.24%	AB, QB
1971-1980	0.84%	AB, BC, QB, ON, NB	9.88%	ON, PEI	7.43%	MB, SAS, PEI, NFL, NB	2.67%	BC, MB, NS	0.71%	QB, ON
1981-1990	0.45%	BC, QB	7.28%	AB, MB, QB	6.00%	BC, MB, ON, NFL	2.14%	BC, NS	1.57%	BC
1991 and after	0.25%	BC, QB, NB	5.38%	BC, QB, NS, PEI, NFL, NB	2.19%	AB, BC, NS, NFL, NB	1.51%	ON	0.77%	BC, QB

Figure 5: Number of additional EGH participants per province

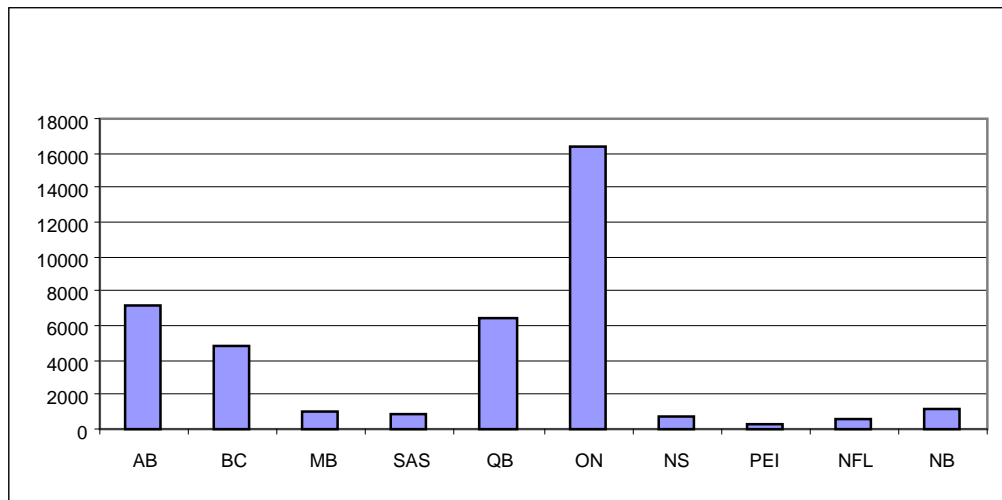
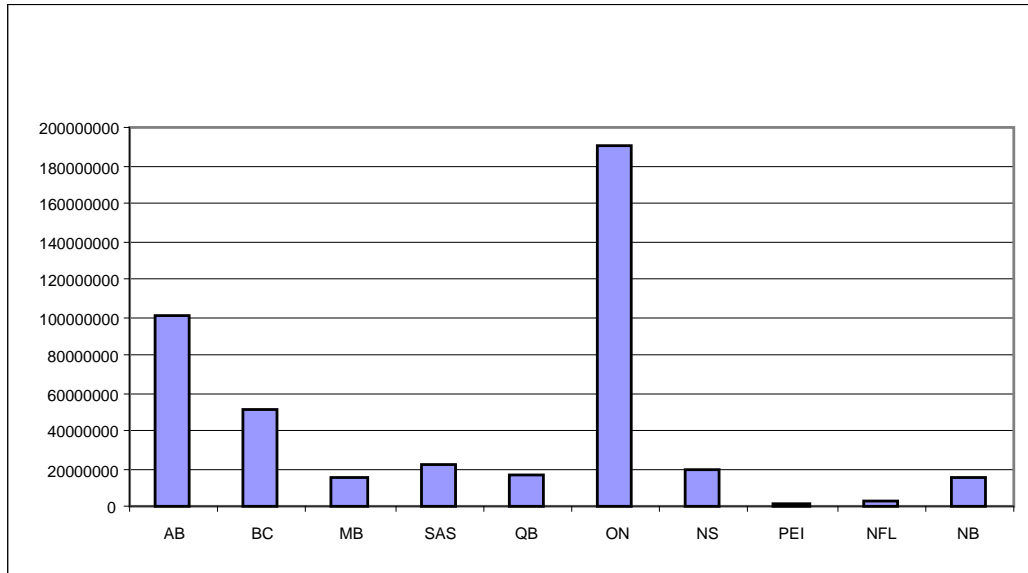


Figure 6: Additional energy saving in megajoules per province



Ontario has the highest potential for improvement in terms of both the number of participants and the amount of energy savings. This is due to its large population, its low initial participation rate, and its high energy savings per case. British Columbia and Alberta also have a large increase, although they already have high participation rates. This is due to the increase in participation for sub-categories where participation is low compared to the Canadian average and to a renovation rate that is often higher in EGH than for the entire population. Conversely, Quebec offers a moderate potential for energy savings in spite of the fact that its initial participation rates are often very low, due to the low share of EGH participants that undertake renovation and a second audit. In the Atlantic region, the same phenomenon occurs; as the renovation rates are often higher for the entire population than for the EGH participants, so increasing EGH participation would involve many households that would undertake renovations regardless, leading to relatively low potential for increases in energy savings from the EGH program in these provinces.

6 Conclusion and further consideration

This paper examines the potential for the voluntary environmental EnerGuide for Houses program to reduce energy consumption in Canada's residential sector. The self-selection of participants into the program makes an assessment of the program's nationwide potential difficult due to the resulting problem of non-randomness in the sample data, a problem often referred to as sample selectivity. The standard approach to addressing this problem would start with the estimation of the probability that an individual household would be included in the sample, but this method cannot be used here due to the absence of information on non-participants in the EGH dataset. Alternative approaches are outlined that make use of supplementary information from other sources, such as that contained in nation-wide Survey of Household Energy Use 2003. It is found, however, that no satisfactory solution to estimating the probability of participation exists, given the particular data that are available. However, an alternative method based on sorting the data from the EGH and SHUE03 data into subgroups is used to obtain an approximation, via the examination of two scenarios, of the extent to which additional household participation in the program could achieve increased energy savings in Canada.

The data analysis in this study shows that EGH participants have distinctive characteristics as compared to the Canadian population as a whole. Households located in Western Canada are more likely to enroll in the program. As well, owners of houses built in the mid-20th century have a greater rate of participation in the program than owners of recently constructed houses. The type of fuel used is also found to influence participation in the program. Finally, participation in the program requires sufficient financial resources, so that households in middle annual income ranges (\$40,000 to \$80,000) are over-represented among EGH participants. The household's decision to undertake one or more retrofits is also influenced by these characteristics, and the ways in which some of these characteristics affect the retrofit decision are not always the same for EGH participants and for the general Canadian population.

The variables found to influence participation in the EGH are used to create a set of mutually exclusive and exhaustive distinct groups among the EGH participants and the Canadian

population. These form the basis for an examination of the participation rate into EGH as well as the renovation rate for each group, providing insight into how the program might realistically be extended to additional households in Canada. A scenario with a uniform increase of the participation rate across all groups is compared to one where participation rates in all provinces are brought up to at least the national average. Although the total energy savings are qualitatively similar under both scenarios, the second scenario better reflects the reality of the potential for the EGH program.

Other approaches to assess the potential of the EGH program could focus on developments of the program that would target certain categories of houses based on the energy savings per household that they realize. Such a program could have a higher potential to achieve energy saving if it were to target the types of houses that have exhibited the highest energy savings in the program so far as energy savings after a second audit vary significantly according to the specific features of the houses that have been retrofitted. This analysis is left for further research.

REFERENCES

- Arora, S. and Cason, T. N. (1995) “An Experiment in Voluntary Environmental Regulation: Participation in EPA’s 33/50 Program” *Journal of Environmental Economics and Management* 28, 271-286.
- Hartman R. S. (1988) “Self-Selection Bias in the Evolution of Voluntary Energy Conservation Programs” *The Review of Economics and Statistics*. 70(3), 448-458
- Pizer W. A., Morgenstern R., and Shih J. S. (2008) “Evaluating Voluntary Climate Programs in the United States” Resources for the Future RFF DP 08-13
- Ryan, D. (2009) “Explaining Energy Savings under the EnerGuide for Houses Home Retrofit Program” CBEEDAC 2009–RP-02-DRAFT
- Swan L. G., Ugursal V. I. and Beausoleil-Morrison I. (2009) “A database of house descriptions representative of the Canadian housing stock for coupling to building energy performance simulation” *Journal of Building Performance Simulation* 2 1–10.

APPENDIX

Appendix A: Variable comparison, EGH and SHEU03

Province

EGH: House Region * Probability_both Crosstabulation

		Probability_both		Total
		.00	1.00	
House Region AB	Count	25017	7463	32480
	% within House Region	77.0%	23.0%	100.0%
	% within Probability_both	19.0%	24.2%	20.0%
BC	Count	20495	4767	25262
	% within House Region	81.1%	18.9%	100.0%
	% within Probability_both	15.6%	15.5%	15.6%
MB	Count	9209	2638	11847
	% within House Region	77.7%	22.3%	100.0%
	% within Probability_both	7.0%	8.6%	7.3%
NB	Count	1276	298	1574
	% within House Region	81.1%	18.9%	100.0%
	% within Probability_both	1.0%	1.0%	1.0%
NF	Count	1619	154	1773
	% within House Region	91.3%	8.7%	100.0%
	% within Probability_both	1.2%	.5%	1.1%
NS	Count	3856	591	4447
	% within House Region	86.7%	13.3%	100.0%
	% within Probability_both	2.9%	1.9%	2.7%
ON	Count	41718	9825	51543
	% within House Region	80.9%	19.1%	100.0%
	% within Probability_both	31.7%	31.9%	31.8%
PEI	Count	402	30	432

	% within House Region	93.1%	6.9%	100.0%
	% within Probability_both	.3%	.1%	.3%
QC	Count	18348	1401	19749
	% within House Region	92.9%	7.1%	100.0%
	% within Probability_both	14.0%	4.5%	12.2%
SASK	Count	9555	3629	13184
	% within House Region	72.5%	27.5%	100.0%
	% within Probability_both	7.3%	11.8%	8.1%
Total	Count	131495	30796	162291
	% within House Region	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: Census Province Code * One or more improvements made to household in 2003 Crosstabulation

			One or more improvements made to household in 2003		Total
			No	Yes	
Census Province Code	Newfoundland and Labrador	Count	141323	23438	164761
		% within Census Province Code	85.8%	14.2%	100.0%
		% within One or more improvements made to household in 2003	2.0%	1.8%	1.9%
Prince Edward Island	Count	28023	6638	34661	
		% within Census Province Code	80.8%	19.2%	100.0%
		% within One or more improvements made to household in 2003	.4%	.5%	.4%
Nova Scotia	Count	231841	53264	285105	
		% within Census Province Code	81.3%	18.7%	100.0%
		% within One or more improvements made to household in 2003	3.2%	4.1%	3.4%
New Brunswick	Count	203518	37171	240689	

	% within Census Province Code	84.6%	15.4%	100.0%
	% within One or more improvements made to household in 2003	2.8%	2.9%	2.8%
Québec	Count	1559101	195079	1754180
	% within Census Province Code	88.9%	11.1%	100.0%
	% within One or more improvements made to household in 2003	21.7%	15.0%	20.7%
Ontario	Count	2714660	655029	3369689
	% within Census Province Code	80.6%	19.4%	100.0%
	% within One or more improvements made to household in 2003	37.7%	50.5%	39.7%
Manitoba	Count	283952	41430	325382
	% within Census Province Code	87.3%	12.7%	100.0%
	% within One or more improvements made to household in 2003	3.9%	3.2%	3.8%
Saskatchewan	Count	280030	49804	329834
	% within Census Province Code	84.9%	15.1%	100.0%
	% within One or more improvements made to household in 2003	3.9%	3.8%	3.9%
Alberta	Count	829768	104360	934128
	% within Census Province Code	88.8%	11.2%	100.0%
	% within One or more improvements made to household in 2003	11.5%	8.0%	11.0%
British Columbia	Count	924349	131161	1055510
	% within Census Province Code	87.6%	12.4%	100.0%
	% within One or more improvements made to household in 2003	12.8%	10.1%	12.4%

Total	Count	7196565	1297374	8493939
	% within Census Province Code	84.7%	15.3%	100.0%
	% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Year of construction

EGH: YearButiltbyGroup * Probability_both Crosstabulation

			Probability_both		Total
			.00	1.00	
YearButiltbyGroup	1945 or less	Count	23596	5566	29162
		% within YearButiltbyGroup	80.9%	19.1%	100.0%
		% within Probability_both	17.9%	18.1%	18.0%
1946-1960	1946-1960	Count	26506	6548	33054
		% within YearButiltbyGroup	80.2%	19.8%	100.0%
		% within Probability_both	20.2%	21.3%	20.4%
1961-1970	1961-1970	Count	21368	6038	27406
		% within YearButiltbyGroup	78.0%	22.0%	100.0%
		% within Probability_both	16.3%	19.6%	16.9%
1971-1980	1971-1980	Count	31741	8696	40437
		% within YearButiltbyGroup	78.5%	21.5%	100.0%
		% within Probability_both	24.1%	28.2%	24.9%
1981-1990	1981-1990	Count	19205	3319	22524
		% within YearButiltbyGroup	85.3%	14.7%	100.0%
		% within Probability_both	14.6%	10.8%	13.9%
1991-1995	1991-1995	Count	4552	370	4922
		% within YearButiltbyGroup	92.5%	7.5%	100.0%
		% within Probability_both	3.5%	1.2%	3.0%
1996-2000	1996-2000	Count	3038	164	3202
		% within YearButiltbyGroup	94.9%	5.1%	100.0%
		% within Probability_both	2.3%	.5%	2.0%

After 2000	Count	1489	95	1584
	% within YearBultbyGroup	94.0%	6.0%	100.0%
	% within Probability_both	1.1%	.3%	1.0%
Total	Count	131495	30796	162291
	% within YearBultbyGroup	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: Year of Building Construction * One or more improvements made to household in 2003

Crosstabulation

			One or more improvements made to household in 2003		Total
			No	Yes	
Year of Building Construction	Built between 1900 and 1909	Count	328485	117915	446400
		% within Year of Building Construction	73.6%	26.4%	100.0%
		% within One or more improvements made to household in 2003	4.6%	9.1%	5.3%
	Built between 1910 and 1919	Count	124222	20511	144733
		% within Year of Building Construction	85.8%	14.2%	100.0%
		% within One or more improvements made to household in 2003	1.7%	1.6%	1.7%
	Built between 1920 and 1929	Count	168396	54295	222691
		% within Year of Building Construction	75.6%	24.4%	100.0%
		% within One or more improvements made to household in 2003	2.3%	4.2%	2.6%
	Built between 1930 and 1939	Count	116722	35323	152045
		% within Year of Building Construction	76.8%	23.2%	100.0%

	% within One or more improvements made to household in 2003	1.6%	2.7%	1.8%
Built between 1940 and 1949	Count	359188	98578	457766
	% within Year of Building Construction	78.5%	21.5%	100.0%
	% within One or more improvements made to household in 2003	5.0%	7.6%	5.4%
Built between 1950 and 1959	Count	809985	215696	1025681
	% within Year of Building Construction	79.0%	21.0%	100.0%
	% within One or more improvements made to household in 2003	11.3%	16.6%	12.1%
Built between 1960 and 1969	Count	926149	170126	1096275
	% within Year of Building Construction	84.5%	15.5%	100.0%
	% within One or more improvements made to household in 2003	12.9%	13.1%	12.9%
Built between 1970 and 1979	Count	1418564	248747	1667311
	% within Year of Building Construction	85.1%	14.9%	100.0%
	% within One or more improvements made to household in 2003	19.7%	19.2%	19.6%
Built between 1980 and 1989	Count	1337658	208702	1546360
	% within Year of Building Construction	86.5%	13.5%	100.0%
	% within One or more improvements made to household in 2003	18.6%	16.1%	18.2%
Built between	Count	1234387	90038	1324425

	% within Year of Building Construction	93.2%	6.8%	100.0%
	% within One or more improvements made to household in 2003	17.2%	6.9%	15.6%
Built after 1999	Count	372808	37442	410250
	% within Year of Building Construction	90.9%	9.1%	100.0%
	% within One or more improvements made to household in 2003	5.2%	2.9%	4.8%
Total	Count	7196564	1297373	8493937
	% within Year of Building Construction	84.7%	15.3%	100.0%
	% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Type of house

EGH: Type of House * Probability_both Crosstabulation

		Probability_both		Total
		.00	1.00	
Type of House Row	Count	2309	519	2828
	% within Type of House	81.6%	18.4%	100.0%
	% within Probability_both	1.8%	1.7%	1.7%
Row house, end unit	Count	6100	1159	7259
	% within Type of House	84.0%	16.0%	100.0%
	% within Probability_both	4.6%	3.8%	4.5%
Row house, middle unit	Count	1414	232	1646
	% within Type of House	85.9%	14.1%	100.0%
	% within Probability_both	1.1%	.8%	1.0%
Single Detached	Count	121672	28886	150558

	% within Type of House	80.8%	19.2%	100.0%
	% within Probability_both	92.5%	93.8%	92.8%
Total	Count	131495	30796	162291
	% within Type of House	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: Dwelling types - CCHS derived * One or more improvements made to household in 2003

Crosstabulation

			One or more improvements made to household in 2003		Total
			No	Yes	
Dwelling types - CCHS derived	Single detached	Count	6068993	1122547	7191540
		% within Dwelling types - CCHS derived	84.4%	15.6%	100.0%
		% within One or more improvements made to household in 2003	84.3%	86.5%	84.7%
	Double	Count	547243	72570	619813
		% within Dwelling types - CCHS derived	88.3%	11.7%	100.0%
		% within One or more improvements made to household in 2003	7.6%	5.6%	7.3%
	Row or terrace	Count	580330	102256	682586
		% within Dwelling types - CCHS derived	85.0%	15.0%	100.0%
		% within One or more improvements made to household in 2003	8.1%	7.9%	8.0%
Total		Count	7196566	1297373	8493939
		% within Dwelling types - CCHS derived	84.7%	15.3%	100.0%
		% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Size of the house

EGH: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Foot Print (sum of floor areas, Msqr)	162291	13.0	576.5	92.564	33.2459
Valid N (listwise)	162291				

SHEU: Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
heated area all sq ft	7627014	15	54450	1544.15	1600.629
Valid N (listwise)	7627014				

Income

EGH: Income_group * Probability_both Crosstabulation

		Probability_both		Total
		.00	1.00	
Income_group 80.00	Count	21970	4799	26769
	% within Income_group	82.1%	17.9%	100.0%
	% within Probability_both	16.7%	15.6%	16.5%
2040.00	Count	5223	980	6203
	% within Income_group	84.2%	15.8%	100.0%
	% within Probability_both	4.0%	3.2%	3.8%
4060.00	Count	65468	15571	81039
	% within Income_group	80.8%	19.2%	100.0%
	% within Probability_both	49.8%	50.6%	49.9%
6080.00	Count	38834	9446	48280
	% within Income_group	80.4%	19.6%	100.0%
	% within Probability_both	29.5%	30.7%	29.7%

Total	Count	131495	30796	162291
	% within Income_group	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: Household Income * One or more improvements made to household in 2003 Crosstabulation

			One or more improvements made to household in 2003		Total
			No	Yes	
Household Income	Household Income is between \$0 and \$20000	Count	617046	100385	717431
		% within Household Income	86.0%	14.0%	100.0%
		% within One or more improvements made to household in 2003	11.3%	9.5%	11.0%
Household Income	Household Income is between \$20000 and \$40000	Count	1148776	212527	1361303
		% within Household Income	84.4%	15.6%	100.0%
		% within One or more improvements made to household in 2003	20.9%	20.2%	20.8%
Household Income	Household Income is between \$40000 and \$60000	Count	1249385	260054	1509439
		% within Household Income	82.8%	17.2%	100.0%
		% within One or more improvements made to household in 2003	22.8%	24.7%	23.1%
Household Income	Household Income is between \$60000 and \$80000	Count	874759	178168	1052927
		% within Household Income	83.1%	16.9%	100.0%
		% within One or more improvements made to household in 2003	16.0%	16.9%	16.1%
Household Income	Household Income is between \$80000 and	Count	778339	154914	933253
		% within Household Income	83.4%	16.6%	100.0%

	% within One or more improvements made to household in 2003	14.2%	14.7%	14.3%
Household Income is greater than \$100000	Count	815622	147039	962661
	% within Household Income	84.7%	15.3%	100.0%
	% within One or more improvements made to household in 2003	14.9%	14.0%	14.7%
Total	Count	5483927	1053087	6537014
	% within Household Income	83.9%	16.1%	100.0%
	% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Storeys

EGH: Number of Storeys * Probability_both Crosstabulation

		Probability_both		Total
		.00	1.00	
Number of Storeys One and a half Count		4629	1087	5716
% within Number of Storeys		81.0%	19.0%	100.0%
% within Probability_both		3.5%	3.5%	3.5%
One storey	Count	65405	16652	82057
	% within Number of Storeys	79.7%	20.3%	100.0%
	% within Probability_both	49.7%	54.1%	50.6%
Three storeys	Count	3872	710	4582
	% within Number of Storeys	84.5%	15.5%	100.0%
	% within Probability_both	2.9%	2.3%	2.8%
Two and a half	Count	1182	268	1450
	% within Number of Storeys	81.5%	18.5%	100.0%
	% within Probability_both	.9%	.9%	.9%
Two storeys	Count	56407	12079	68486

	% within Number of Storeys	82.4%	17.6%	100.0%
	% within Probability_both	42.9%	39.2%	42.2%
Total	Count	131495	30796	162291
	% within Number of Storeys	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: Excluding the basement, how many storeys * One or more improvements made to household in 2003

Crosstabulation

			One or more improvements made to household in 2003		Total
			No	Yes	
Excluding the basement, how many storeys	One storey	Count	3662985	561460	4224445
		% within Excluding the basement, how many storeys	86.7%	13.3%	100.0%
		% within One or more improvements made to household in 2003	50.9%	43.3%	49.7%
One and half storeys	One and half storeys	Count	673018	180148	853166
		% within Excluding the basement, how many storeys	78.9%	21.1%	100.0%
		% within One or more improvements made to household in 2003	9.4%	13.9%	10.0%
Two storeys	Two storeys	Count	2336529	466064	2802593
		% within Excluding the basement, how many storeys	83.4%	16.6%	100.0%
		% within One or more improvements made to household in 2003	32.5%	35.9%	33.0%
Two and one half storeys	Two and one half storeys	Count	43449	12561	56010
		% within Excluding the basement, how many storeys	77.6%	22.4%	100.0%

	% within One or more improvements made to household in 2003	.6%	1.0%	.7%
Three storeys	Count	163266	24860	188126
	% within Excluding the basement, how many storeys	86.8%	13.2%	100.0%
	% within One or more improvements made to household in 2003	2.3%	1.9%	2.2%
Split level	Count	266346	45102	311448
	% within Excluding the basement, how many storeys	85.5%	14.5%	100.0%
	% within One or more improvements made to household in 2003	3.7%	3.5%	3.7%
Other - Specify	Count	50973	7178	58151
	% within Excluding the basement, how many storeys	87.7%	12.3%	100.0%
	% within One or more improvements made to household in 2003	.7%	.6%	.7%
Total	Count	7196566	1297373	8493939
	% within Excluding the basement, how many storeys	84.7%	15.3%	100.0%
	% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Furnace fuel type

Furnace Fuel Type * Probability_both Crosstabulation

		Probability_both		Total
		.00	1.00	
Furnace Fuel Type Electricity	Count	22063	2051	24114
	% within Furnace Fuel Type	91.5%	8.5%	100.0%
	% within Probability_both	16.8%	6.7%	14.9%
Hardwood	Count	278	19	297
	% within Furnace Fuel Type	93.6%	6.4%	100.0%
	% within Probability_both	.2%	.1%	.2%
Mixed wood	Count	244	22	266
	% within Furnace Fuel Type	91.7%	8.3%	100.0%
	% within Probability_both	.2%	.1%	.2%
Natural Gas	Count	93904	25614	119518
	% within Furnace Fuel Type	78.6%	21.4%	100.0%
	% within Probability_both	71.4%	83.2%	73.6%
Oil	Count	14164	2974	17138
	% within Furnace Fuel Type	82.6%	17.4%	100.0%
	% within Probability_both	10.8%	9.7%	10.6%
Propane	Count	791	112	903
	% within Furnace Fuel Type	87.6%	12.4%	100.0%
	% within Probability_both	.6%	.4%	.6%
Softwood	Count	29	2	31
	% within Furnace Fuel Type	93.5%	6.5%	100.0%
	% within Probability_both	.0%	.0%	.0%
Wood	Count	6	1	7
	% within Furnace Fuel Type	85.7%	14.3%	100.0%
	% within Probability_both	.0%	.0%	.0%
Wood Pellets	Count	16	1	17

	% within Furnace Fuel Type	94.1%	5.9%	100.0%
	% within Probability_both	.0%	.0%	.0%
Total	Count	131495	30796	162291
	% within Furnace Fuel Type	81.0%	19.0%	100.0%
	% within Probability_both	100.0%	100.0%	100.0%

SHEU: What source of energy did your (furnace/ * One or more improvements made to household in 2003

Crosstabulation

		One or more improvements made to household in 2003		Total	
		No	Yes		
What source of energy did your (furnace/	Electricity	Count	220590	17391	237981
		% within What source of energy did your (furnace/	92.7%	7.3%	100.0%
		% within One or more improvements made to household in 2003	4.6%	1.9%	4.1%
Natural gas	Count	3644666	634897	4279563	
		% within What source of energy did your (furnace/	85.2%	14.8%	100.0%
		% within One or more improvements made to household in 2003	75.4%	69.4%	74.4%
Oil	Count	609476	160527	770003	
		% within What source of energy did your (furnace/	79.2%	20.8%	100.0%
		% within One or more improvements made to household in 2003	12.6%	17.6%	13.4%
Wood	Count	282630	75218	357848	
		% within What source of energy did your (furnace/	79.0%	21.0%	100.0%

	% within One or more improvements made to household in 2003	5.8%	8.2%	6.2%
Propane	Count	40267	21564	61831
	% within What source of energy did your (furnace/	65.1%	34.9%	100.0%
	% within One or more improvements made to household in 2003	.8%	2.4%	1.1%
Other - Specify	Count	5089	2207	7296
	% within What source of energy did your (furnace/	69.8%	30.2%	100.0%
	% within One or more improvements made to household in 2003	.1%	.2%	.1%
Not stated	Count	33590	2660	36250
	% within What source of energy did your (furnace/	92.7%	7.3%	100.0%
	% within One or more improvements made to household in 2003	.7%	.3%	.6%
Total	Count	4836308	914464	5750772
	% within What source of energy did your (furnace/	84.1%	15.9%	100.0%
	% within One or more improvements made to household in 2003	100.0%	100.0%	100.0%

Reason for no improvement (SHEU)

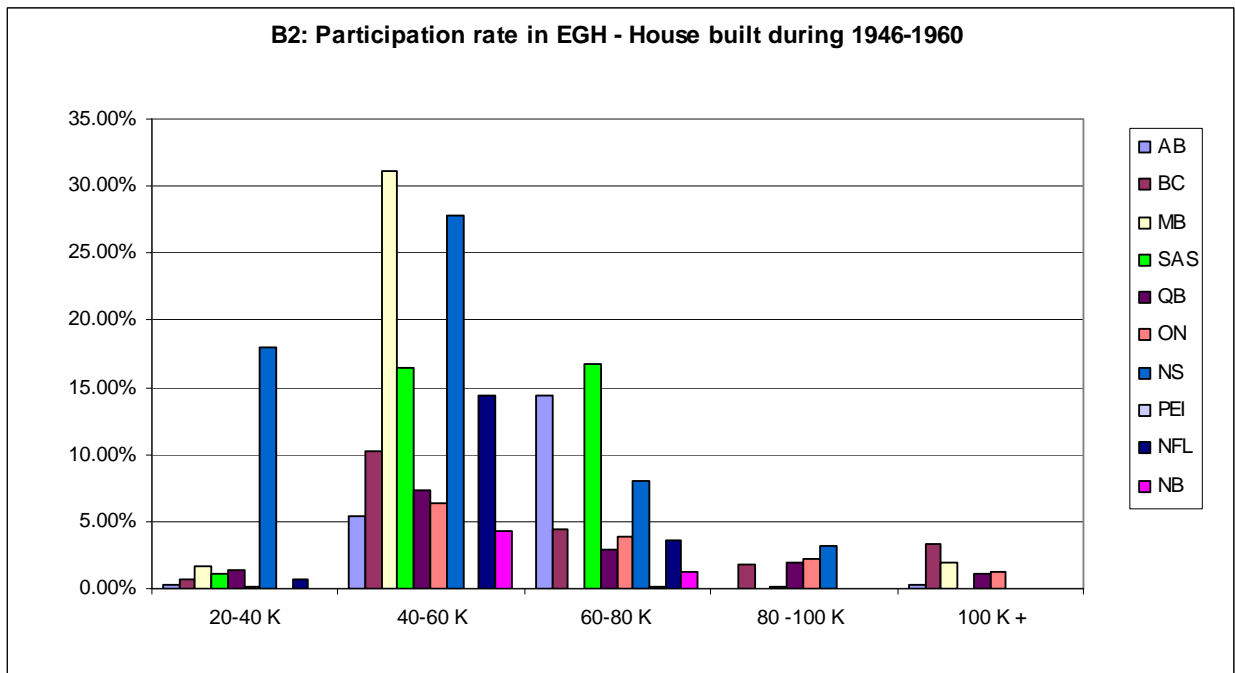
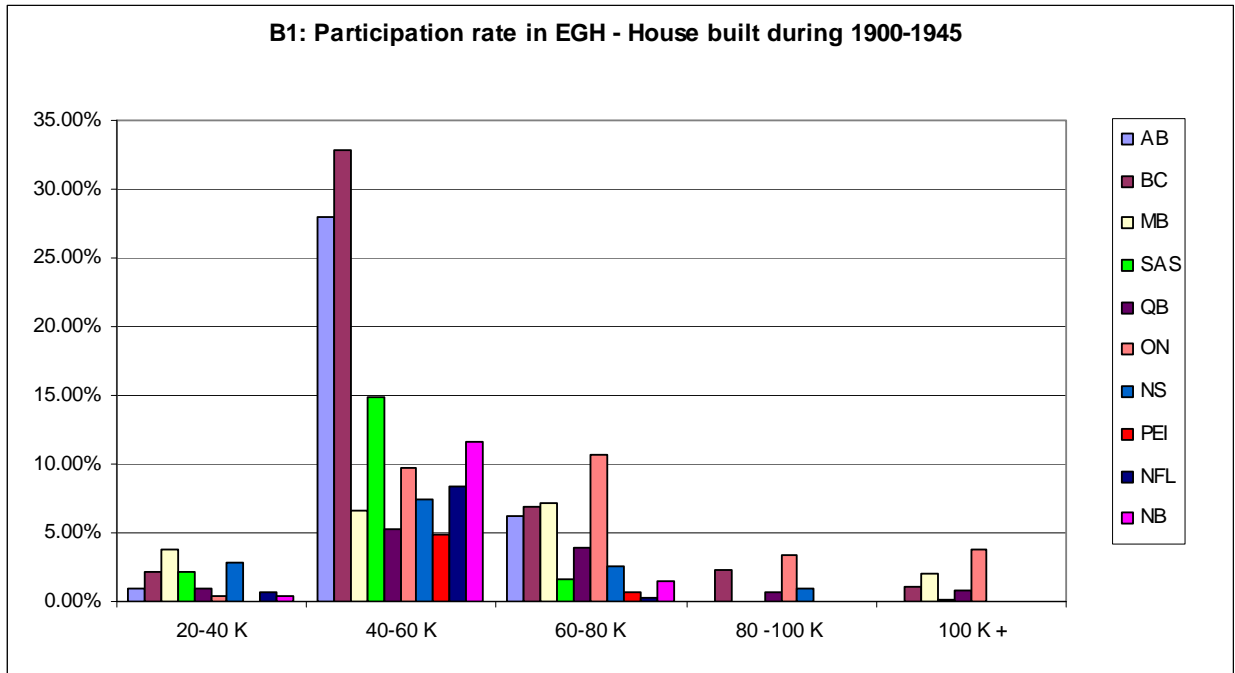
Derived Variable - IMP_D03 * One or more improvements made to household in 2003 Crosstabulation

	One or more improvements made to household in 2003	
	No	Total

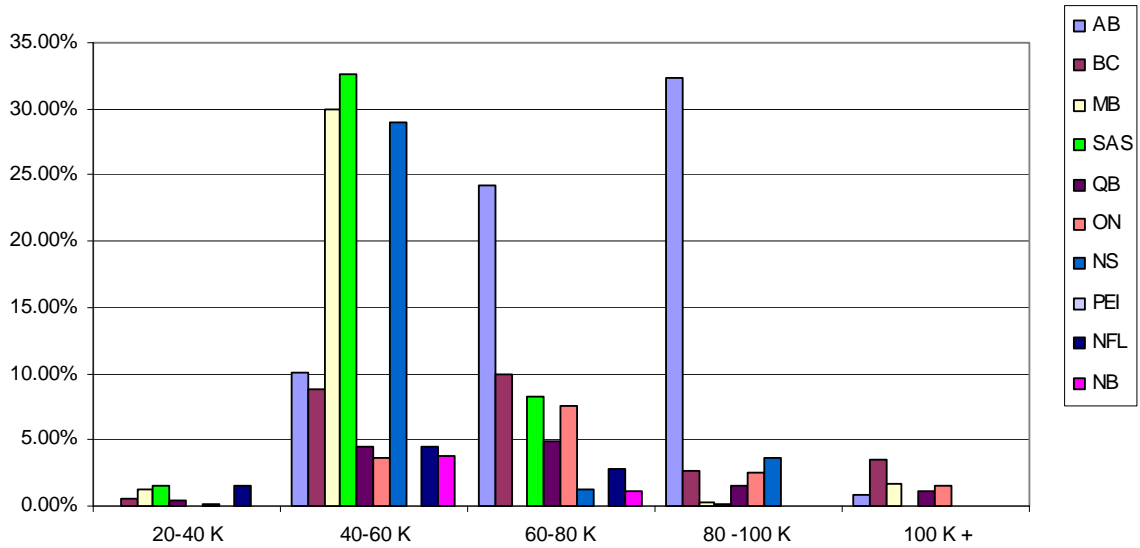
Derived Variable - IMP_D03	No improvements necessary	Count	4058253	4058253
		% within One or more improvements made to household in 2003	66.0%	66.0%
	Improvements too costly	Count	1049478	1049478
		% within One or more improvements made to household in 2003	17.1%	17.1%
	Not aware of government financial aid or assistance	Count	61152	61152
		% within One or more improvements made to household in 2003	1.0%	1.0%
	No government financial aid or assistance	Count	34855	34855
		% within One or more improvements made to household in 2003	.6%	.6%
	Do not have time	Count	80097	80097
		% within One or more improvements made to household in 2003	1.3%	1.3%
Other - Specify	Count	594599	594599	
	% within One or more improvements made to household in 2003	9.7%	9.7%	
Don't know	Count	1095	1095	
	% within One or more improvements made to household in 2003	.0%	.0%	
Refusal	Count	766	766	
	% within One or more improvements made to household in 2003	.0%	.0%	
Not stated	Count	271476	271476	

	% within One or more improvements made to household in 2003	4.4%	4.4%
Total	Count	6151771	6151771
	% within One or more improvements made to household in 2003	100.0%	100.0%

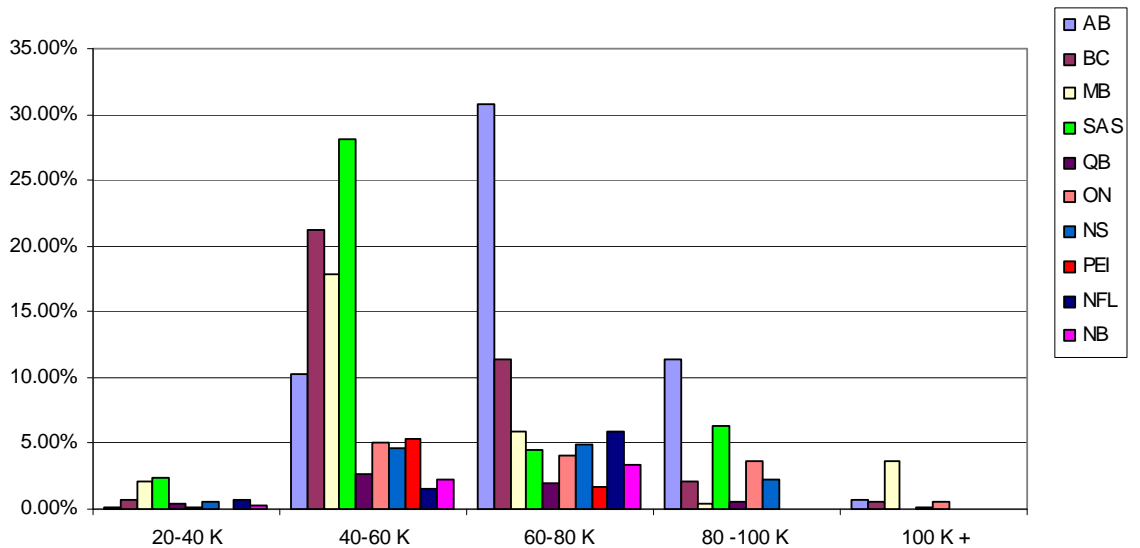
Appendix B: Graphs of Participation Rates



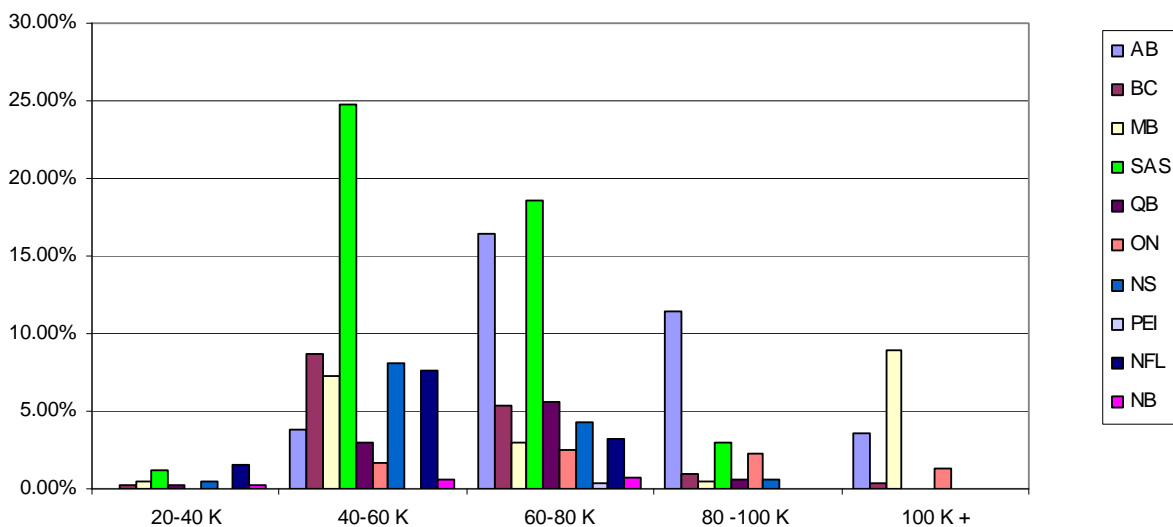
B3: Participation rate in EGH - House built during 1961-1970



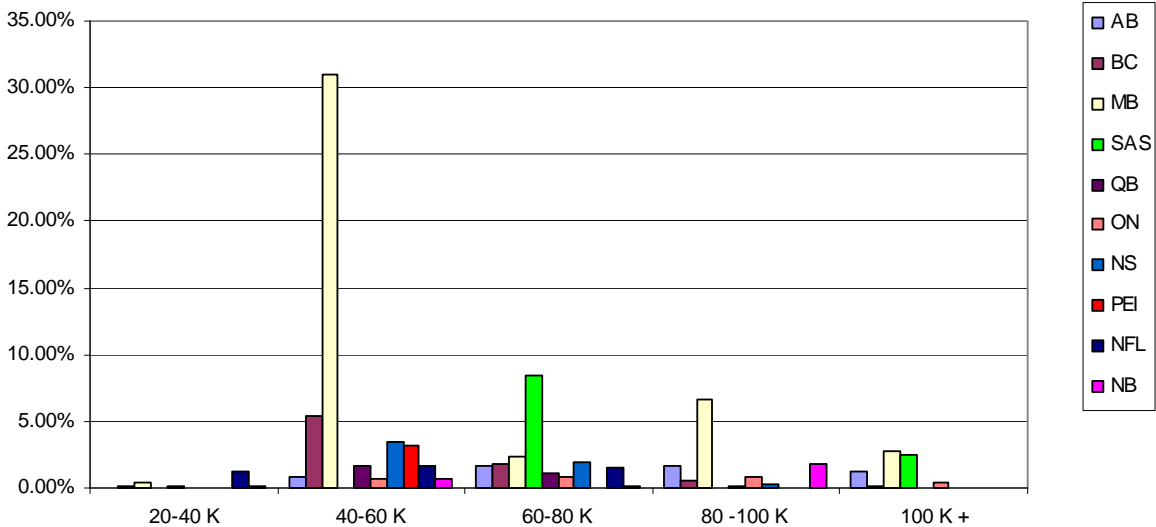
B4: Participation rate in EGH - House built during 1971-1980



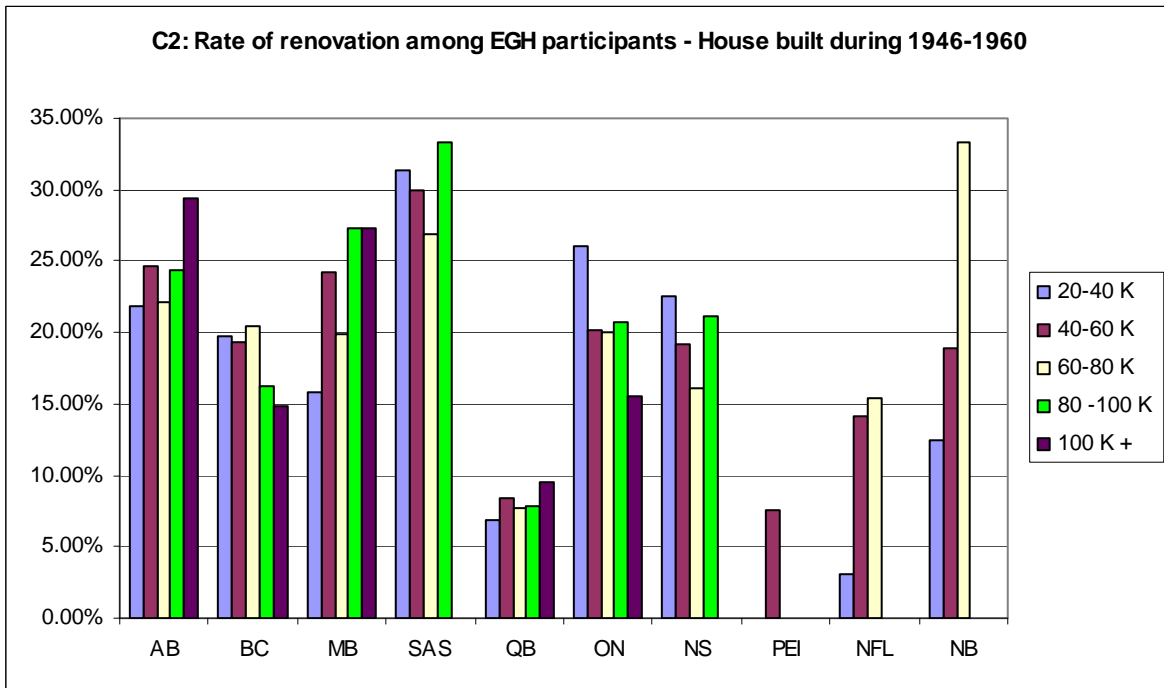
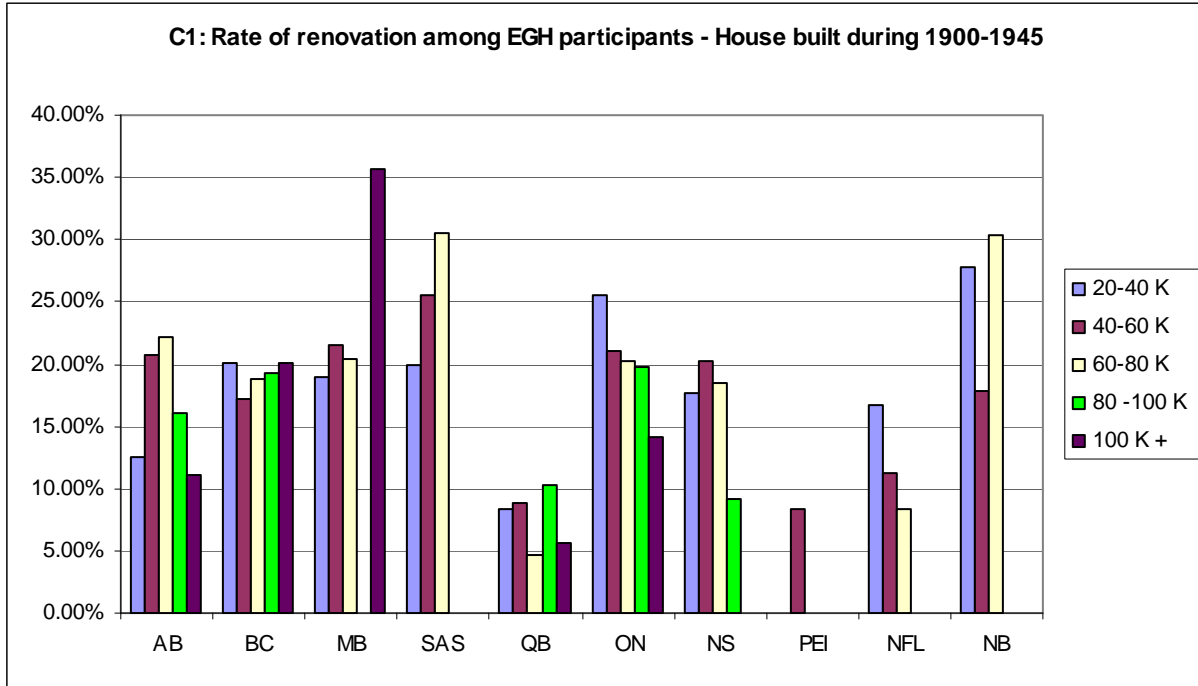
B5: Participation rate in EGH - House built during 1981-1990



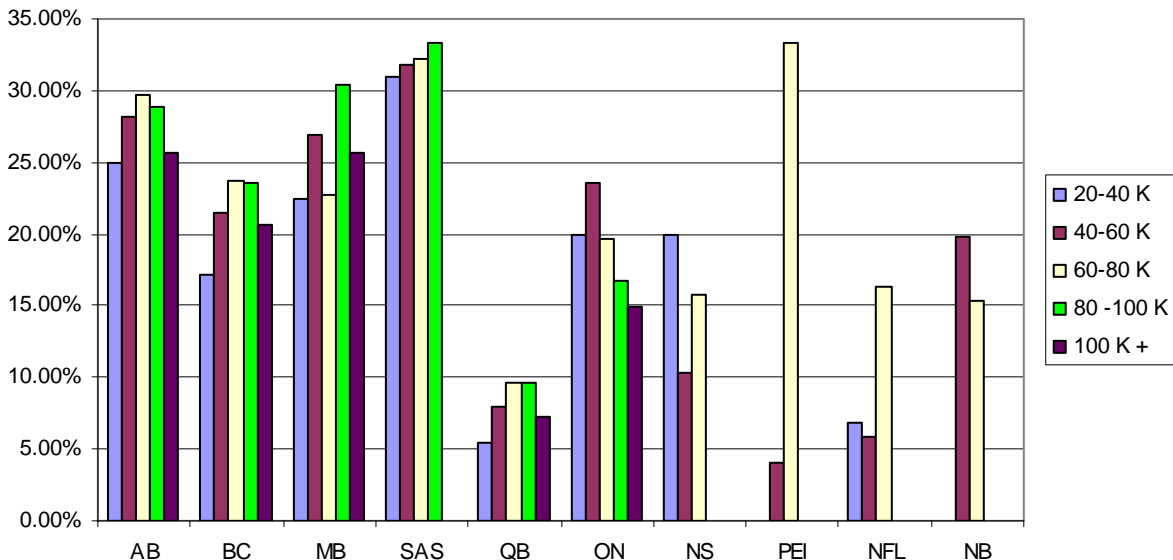
B6: Participation rate in EGH - House built after 1991



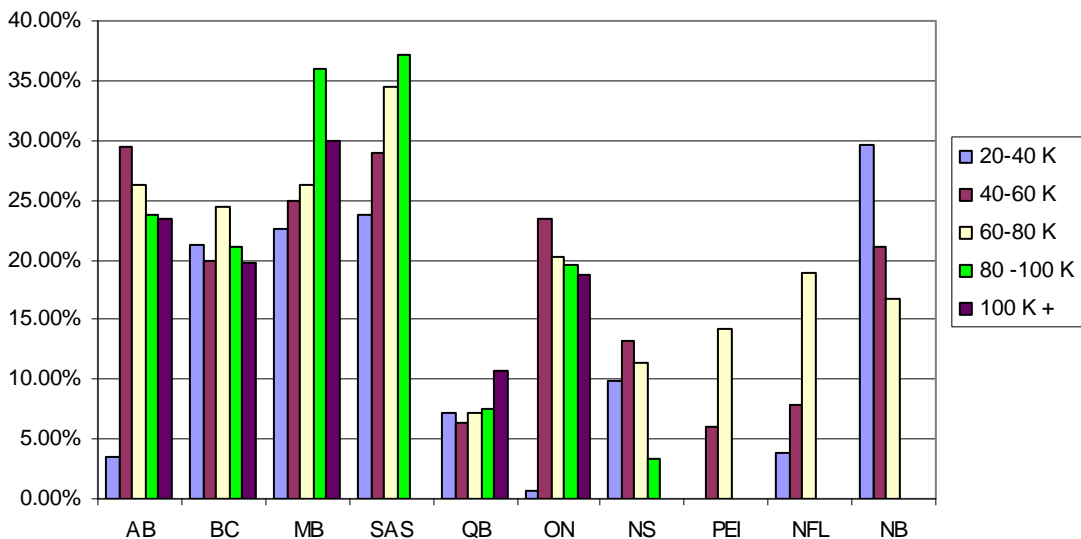
Appendix C: Graphs of Renovation rates

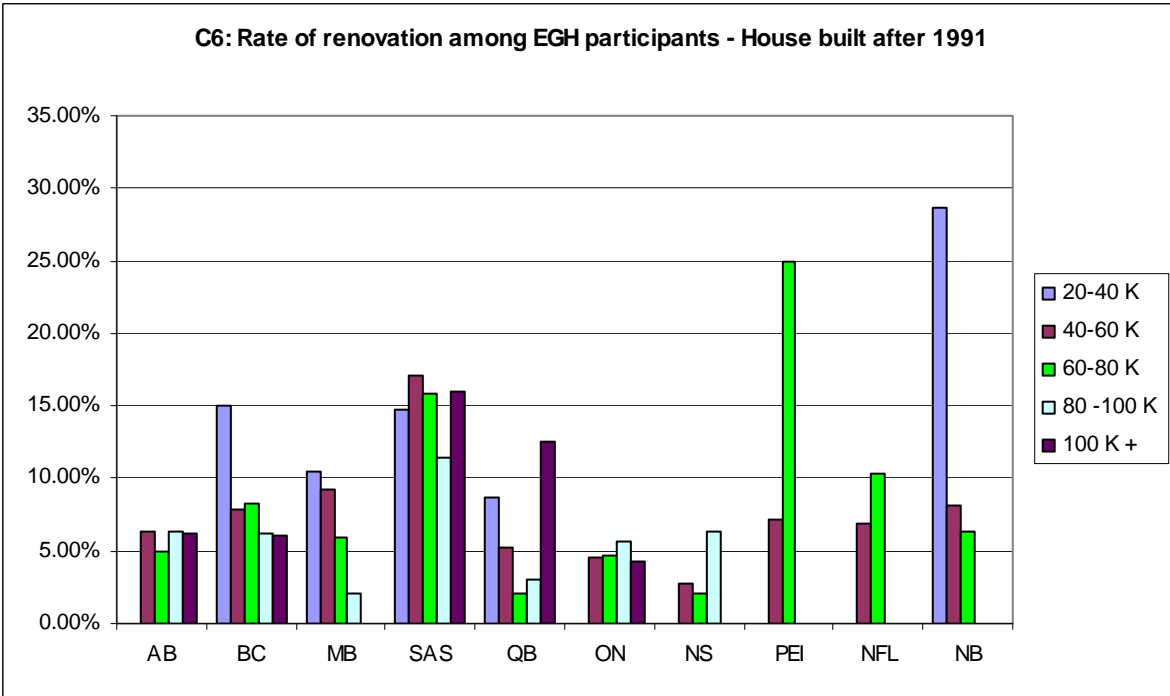
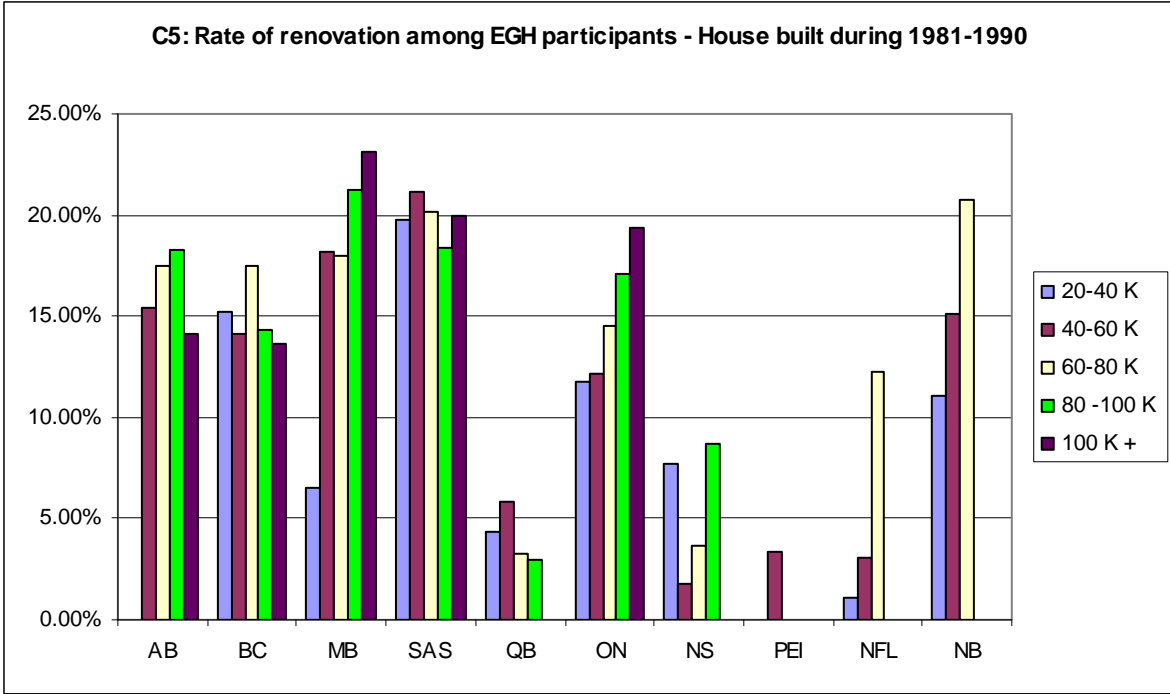


C3: Rate of renovation among EGH participants - House built during 1961-1970

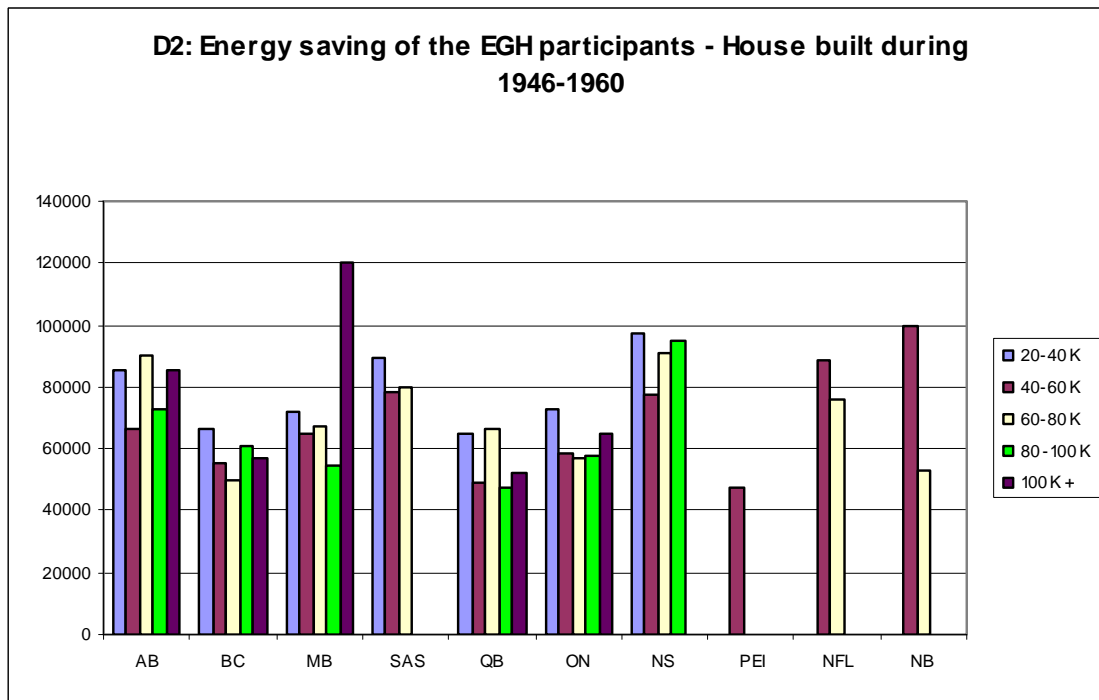
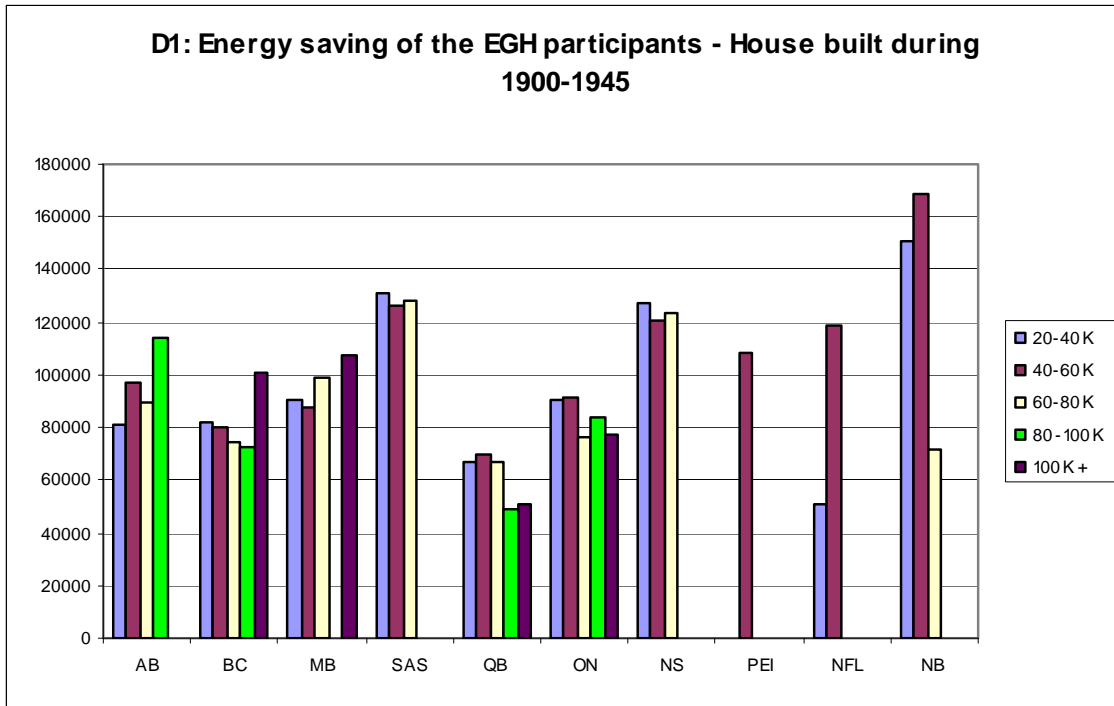


C4: Rate of renovation among EGH participants - House built during 1971-1980

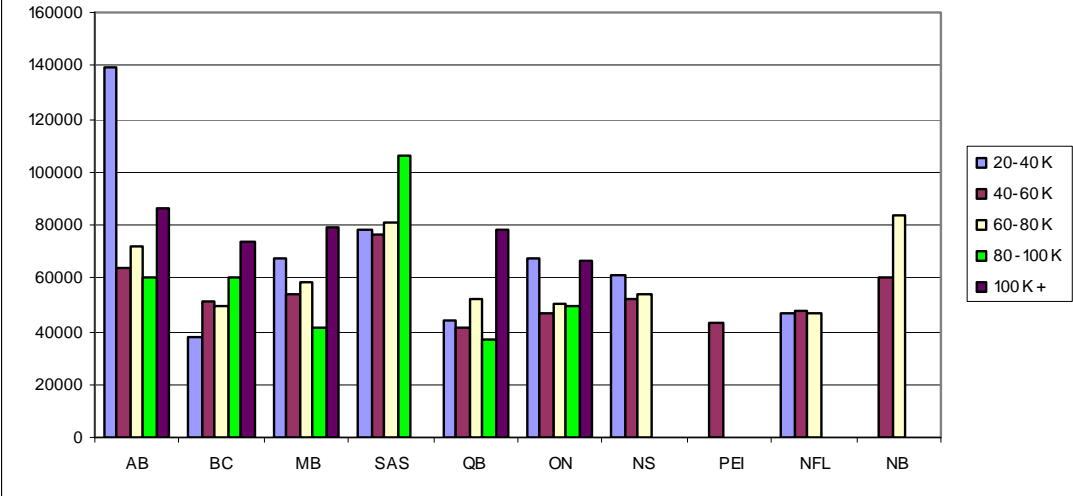




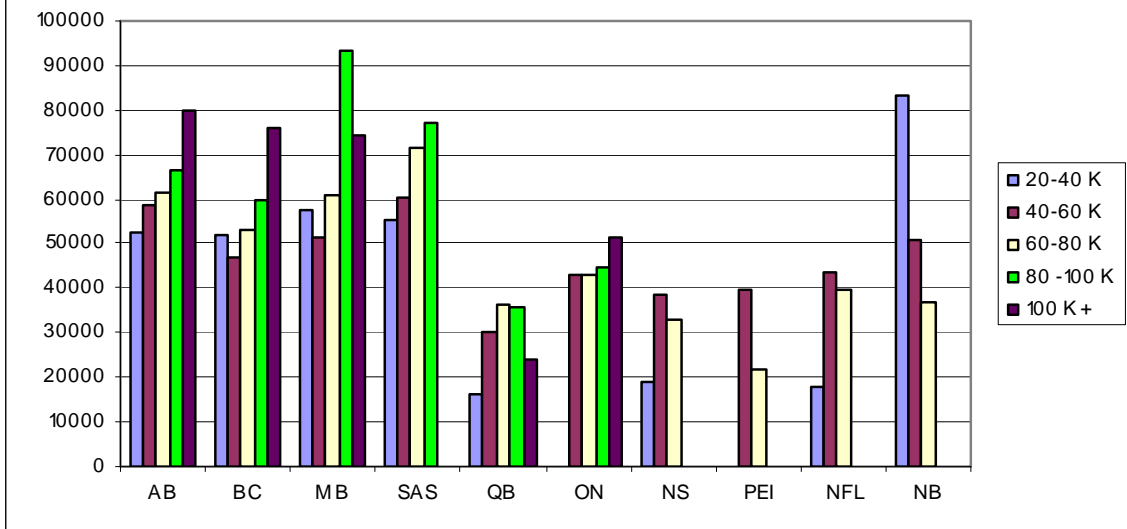
Appendix D: Graphs of Energy savings



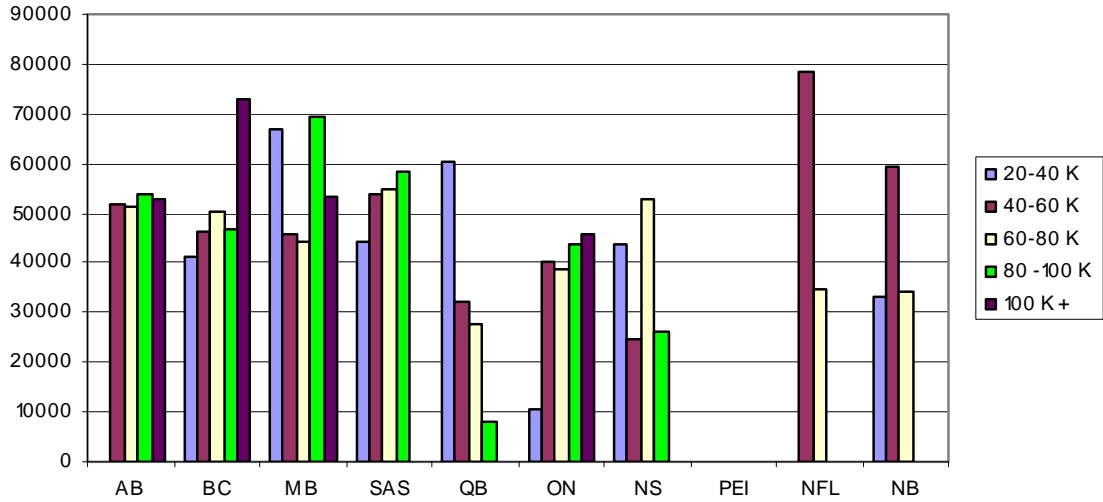
D3: Energy saving of the EGH participants - House built during 1961-1970



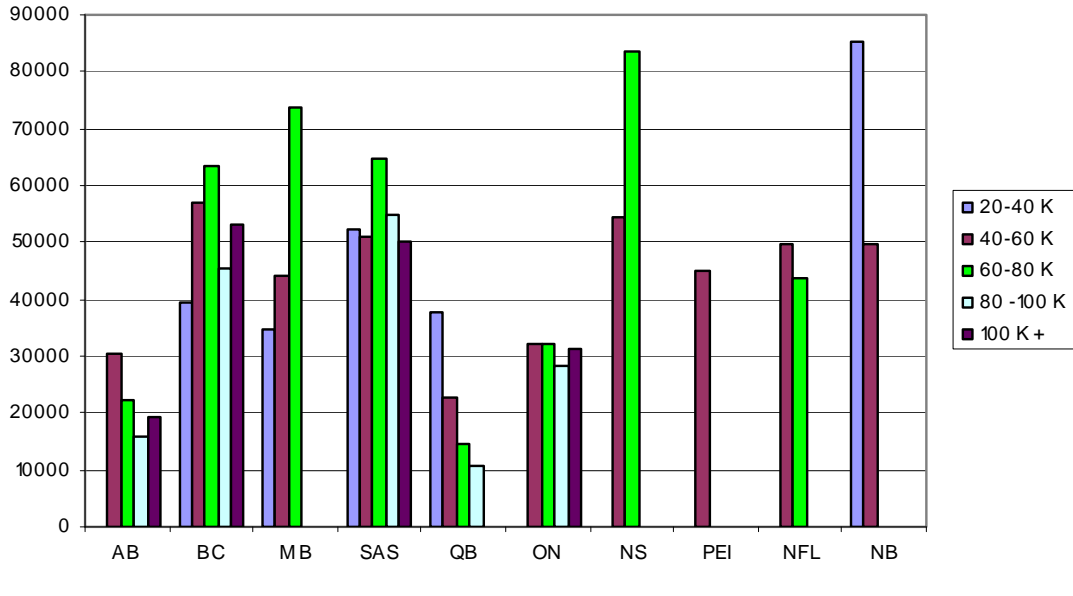
D4: Energy saving of the EGH participants - House built during 1971-1980



D5: Energy saving of the EGH participants - House built during 1981-1990



D6: Energy saving of the EGH participants - House built after 1991



Appendix E: Tables

Table 6: Energy saving in megajoules, before and after a 10% increase of the participation rate in EGH

		1900-1945	1946-1960	1961-1970	1971-1980	1981-1990	1991 and after	Total
AB	Total EGH	44928996	1.13E+08	1.17E+08	1.57E+08	45140581	2857645	478798003
	Total*1.1	49421896	1.24E+08	1.28E+08	1.72E+08	49654639	3143410	526677803
BC	Total EGH	40263570	41701030	57414557	87468289	26954146	10129809	263931401
	Total*1.1	44289927	45871133	63156013	96215118	29649561	11142790	290324541
MB	Total EGH	60121891	44800578	29243519	32765100	8068837	1128922	176128847
	Total*1.1	66134080	49280636	32167871	36041610	8875721	1241814	193741732
SAS	Total EGH	60573596	61051422	64483468	68277577	20191605	4643123	279220791
	Total*1.1	66630956	67156564	70931815	75105335	22210766	5107435	307142870
QB	Total EGH	16853511	19233062	12373543	10503238	3990467	1107078	64060899
	Total*1.1	18538862	21156368	13610897	11553562	4389514	1217786	70466988.9
ON	Total EGH	247188869	1.31E+08	78455436	82844942	50043807	3953452	593966897
	Total*1.1	271907756	1.45E+08	86300980	91129436	55048188	4348797	653363587
NS	Total EGH	30462229	12972255	2826137	3568078	705388	601292	51135379
	Total*1.1	33508452	14269481	3108751	3924886	775926.8	661421.2	56248916.9
PEI	Total EGH	757239	142941	129183	402404	0	90296	1522063
	Total*1.1	832962.9	157235.1	142101.3	442644.4	0	99325.6	1674269.3
NFL	Total EGH	3165702	3391998	1040397	1517660	904600	560670	10581027
	Total*1.1	3482272.2	3731198	1144437	1669426	995060	616737	11639129.7
NB	Total EGH	11966866	6005580	2861820	4129218	1188747	419044	26571275.2
	Total*1.1	13163553	6606138	3148002	4542140	1307622	460948.4	29228402.7
Total	Total EGH							1945916582
	Total*1.1							2140508241

Table 7: Results of the potential according to scenario 2

	number of additional participants	additional saving in mega joules
AB	7232.748901	100378885
BC	4820.64208	50925816
MB	1053.846499	15117636
SAS	817.8794088	22243241
QB	6409.019849	16046823
ON	16338.0766	189900391
NS	734.7388198	19955940
PEI	288.3624601	838365.52
NFL	657.6801918	2323346.2
NB	1148.744672	15655257
Total Canada	39501.73948	433385701

CBEEDAC
Department of Economics
University of Alberta
8-14 Tory Building
Edmonton, Alberta
Canada
T6G 2H4

COPYRIGHT © 2009

Use of materials and information

This publication is protected by copyright; it may be reproduced in unaltered form for personal, non-commercial use. Selected passages and other extracts from this publication may also be reproduced, as long as appropriate credit is granted and CBEEDAC is acknowledged as the source. All other rights are reserved. CBEEDAC will not be liable for any loss, damage, cost or expense incurred in or arising by reason of any person relying on the information in this publication.