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Lukas G. Swan [a]; V. Ismet Ugursal [a]; Ian Beausoleil-Morrison [b]
[a] Department of Mechanical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada [b] Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Ontario, Canada

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A database of house descriptions representative of the Canadian housing stock for coupling to building energy performance simulation

Lukas G. Swan[a]*, V. Ismet Ugursal[a] and Ian Beausoleil-Morrison[b]

[a]*Department of Mechanical Engineering, Dalhousie University, Halifax, Nova Scotia, Canada;* [b]*Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Ontario, Canada*

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The development of a simulation tool that can accurately characterize the energy performance of the Canadian housing stock would enable detailed studies to predict the impact of energy saving upgrades and technologies on a national scale. Such a tool requires a detailed database of house descriptions that collectively represent the entire housing stock. Such a database has been assembled by selectively extracting measured and observed data collected by professionals who conducted on-site audits of 200,000 houses. The auditors' data were extracted to statistically match key parameters (location, house type, vintage, geometry and heating system) with a broad-based random survey of the Canadian stock. The result is a database comprised of nearly 17,000 detailed records of single-detached, double and row houses. Each of these house records represents $\sim$500 houses in the Canadian stock and contains sufficient data to enable the accurate characterization of its energy performance through building performance simulation.

Keywords: residential energy; residential model; housing stock; housing database; residential database

1. Introduction

The housing stock constitutes over 17% of the Canadian end-use energy consumption (OEE 2006b). This consumption is composed of domestic appliance uses, lighting, ventilation, cooling and heating. As its climate dictates significant heating energy, Canada has had incentive programmes in place for over three decades to support upgrades or the addition of technologies to the housing envelope and the space heating systems through the R-2000, EnerGuide and ecoAction programmes (OEE 2004, 2005, 2007). As residential energy consumption is further scrutinized, a nationally and regionally representative energy model of the Canadian housing stock (CHS) is required to estimate the impact that upgrades or additions of technology may have on energy consumption and associated greenhouse gas (GHG) emissions.

To develop such an energy model there is a need for a representative database of houses. It must contain data on each house of sufficient detail for use with sophisticated building energy simulation software that is capable of high-resolution simulation (time step of 1 h or less) to realistically predict the performance of renewable energy technologies.

Key to the database is a large number of houses which represent the CHS. This should encompass the variety of housing styles, construction materials and techniques, heating equipment and weather conditions. The database must also properly distinguish vintage, allowing for determination of impacts to houses within selected age groups. Quantifications such as these may be used in the assessment of changes to the national building or energy codes. Incorporating the wide variety of houses of the CHS, although remaining regionally representative, allows for targeted application of upgrades or technologies to meet desired reductions in energy consumption or GHG emissions.

This article describes the development process and characteristics of a new database that represents the Canadian stock of single-detached (SD), double and row (DR) houses. The database is both nationally and regionally representative with respect to the parameters used in its development. This database forms the foundation of a tool based upon building performance simulation for accurately predicting the end-use energy and related environmental emissions of the CHS.

2. Data sources

To develop a residential database for energy simulation that statistically represents and is inclusive of the wide variety of houses of the CHS, detailed data of house characteristics for a large number of dwellings

*Corresponding author. Email: lswan@dal.ca

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are required. These requirements are met by the EnerGuide for Houses Database (EGHD) and the Survey of Household Energy Use 2003 (SHEU-03).

2.1. EnerGuide for Houses Database

The EGHD (SBC 2006) is the culmination of over 200,000 requested home energy audits that were conducted from 1997 through 2006. The audits, performed by professional auditors, measured and observed the house geometry, construction fabric, air-tightness and heating/cooling equipment. Blais *et al.* (2005) describe in detail the EnerGuide objectives and the development of the EGHD. The basis for the audit was to estimate each house's annual energy consumption, using Natural Resources Canada (NRCan) software HOT2XP® (SBC 2008), and to identify and quantify the energy savings of dwelling upgrades for federal and provincial incentive programmes.

The audit measured and accounted for the following: location and orientation, house type, geometry, number of storeys, foundation type, presence of an attic, construction materials including windows and doors, blower door test results (air-tightness), and domestic hot water (DHW) and space heating system information.

The EGHD only includes SD and DR houses. SD is defined as an entirely separated standalone single housing unit. DR is similar, but shares one or more walls with another house. The EGHD does not include apartments or mobile home dwelling types. Although this is a limitation, the SD and DR dwellings types represent 80% of the CHS by units, as shown in Figure 1 (OEE 2006a). From a national housing energy perspective, the SD and DR house types represent more than 85% of the sector's energy consumption (OEE 2006a). This is because the other significant dwelling type, apartments, typically has fewer walls exposed to ambient conditions and less floor area per dwelling.

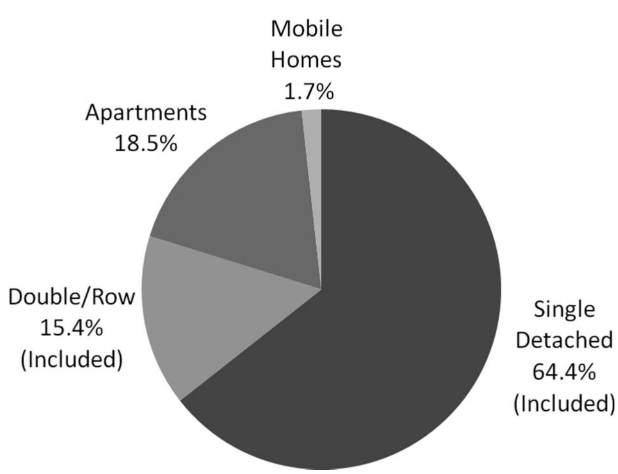

Figure 1. Distribution of the CHS by type. Inclusion in the EGHD is noted.

The EGHD is unprecedented due to its size and parameter inclusion which provides far more detail than most housing databases. For example, the 200,000 records of the EGHD are equal to nearly 2% of the entire population of Canadian residential units, whereas the 50,000 records of the 2005 American Housing Survey (US Census Bureau 2006) are equal to only one-twentieth of a per cent of the population of US residential units.

A 'dataset' composed of 187,821 complete house records from the EGHD, each with over 161 distinct data fields, was provided for this project by NRCan. These data provide the highly detailed information of actual dwellings for use as the source data for this project. However, as the home energy audits of the EGHD were requested by homeowners for incentive purposes, the database is biased and unrepresentative of the CHS. To overcome this bias, a comparison and selection algorithm was developed that used statistically representative descriptive parameters of the CHS as described in Section 3.

2.2. SHEU-03

The SHEU-03 is a housing survey which was designed to quantify the energy use characteristics of the CHS and assess the effectiveness of federal energy efficiency programmes over time (OEE 2006a). The SHEU was conducted in 1993, 1997 and 2003 and is expected to be continued. SHEU-93 provided a baseline for comparison and was the most detailed SHEU survey. Subsequent SHEU surveys have focused more on the level of recent upgrades within dwellings to assess the impact of programmes which support energy efficiency measures.

Statistics Canada conducts SHEU surveys on randomly selected dwellings based on regional population distribution. In this fashion the data are considered unbiased and representative of the CHS. The data for the 2003 survey were collected from 4551 dwellings. The SHEU survey is similar in nature to the USA Residential Energy Consumption Survey (RECS) conducted by the USA Energy Information Administration (EIA 2001), which surveys a similar number of dwellings. RECS includes additional survey information beyond SHEU, although it is not nearly as statistically significant. RECS has a house representation level of 1:25,359, whereas SHEU has a house representation level of 1:2,439.

The survey results of SHEU were extrapolated to the entire CHS of 11.1 million dwellings. SHEU-03 lists parameters such as dwelling type and floor area, but does not include detailed information such as construction materials (most notably insulation) or infiltration/ventilation values which are desirable for energy simulation. Furthermore, individual house records are not publicly available, eliminating the possibility of using the SHEU-03 database for energy simulation.

The results of a statistical analysis of the SHEU-03 database are published as parameter distribution tables as a function of Canadian region or dwelling type (OEE 2006a). Parameter distribution tables further discretized by both Canadian region and dwelling type were provided for this project by the Office of Energy Efficiency (OEE) of NRCan. As they are unbiased and representative of the CHS, the SHEU-03 parameter distributions are used as a guide and the basis of comparison for the selection of dwellings from the EGHD.

3. Methodology

The EGHD dataset is the source from which a subset of nationally and regionally representative houses was selected with respect to certain descriptive house parameters. The selection is based on comparison with the national and regional parameter distributions of the CHS as defined by SHEU-03. This selection technique keeps each detailed house record unmodified and intact and in an open format (delimited ASCII) suitable for a variety of uses.

As it was recognized that the selection procedure would result in fewer houses than the original EGHD dataset, and to limit the number of house records in an effort to promote a reasonable batch energy simulation computational time of less than 1 day,[1] a subset of 18,000–20,000 house records was desired. This is approximately a 10:1 reduction from the original 187,821 EGHD dataset house records.

3.1. Inspection of the EGHD

The received dataset of the EGHD was initially inspected for duplicates caused by resubmission. Using the individual record filenames, 7772 duplicates records were found, and the earlier of the two records was discarded to account for an energy auditor resubmitting to correct a previous error. Filenames were checked for adequate structure (10 alphanumeric characters) resulting in the removal of 173 records. Filenames are of utmost importance as they provide the identification of each house for comparison of future energy simulation investigations. The filename structure includes an alphabetic fifth character which indicates if the file is a first audit ('A'), or a subsequent audit after upgrades or modifications were made to the house (e.g. 'B'). Table 1 shows the distribution of these audit levels. Of the remaining EGHD dataset, 72% are individual houses, of which 38% underwent upgrades and re-evaluation during the EnerGuide programme. As incentive was provided for upgrades, and the level of upgrades of the EnerGuide programme is not considered representative of the CHS, only initial energy audits ('A' records) were considered for the subset database. This reduced the remaining EGHD dataset to 129,389 records.

The remaining set was then divided into the five distinct Canadian regions defined by SHEU-03. They are:

- Atlantic (Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick)
- Quebec
- Ontario
- Prairies (Manitoba, Saskatchewan, and Alberta)
- British Columbia

House records from the territories were discarded due to their low population and limited data. This further reduced the EGHD dataset by 1013 records.

The following key parameters of the houses were tested for validity: vintage, storeys, living space floor area, and DHW and space heating energy sources. Entries that had unrealistic values were discarded. Vintage (constructed prior to 1900) and floor area less than 25 m^2 were the dominant parameters which resulted in the discarding of 6919 houses. Of the original EGHD dataset, 121,456 house records remained: 112,066 SD and 9390 DR type houses.

The distributions of SD and DR houses of the remaining EGHD dataset are shown as a function of region in Figure 2. As the EGHD only includes these dwelling types, the summation of SD and DR values is considered 100%. To provide reference to the CHS, SHEU-03 distributions (also totalled for SD and DR types only) are shown as a thick black outline in Figure 2.

Table 1. Distribution of house audit sequence in the EGHD dataset.

Filename audit sequence	Dwelling count	EGHD dataset (%)	'A' audits (%)
A	129,389	71.9	100.0
B	49,134	27.3	38.0
C	36	0.0	0.0
Other	1317	0.7	

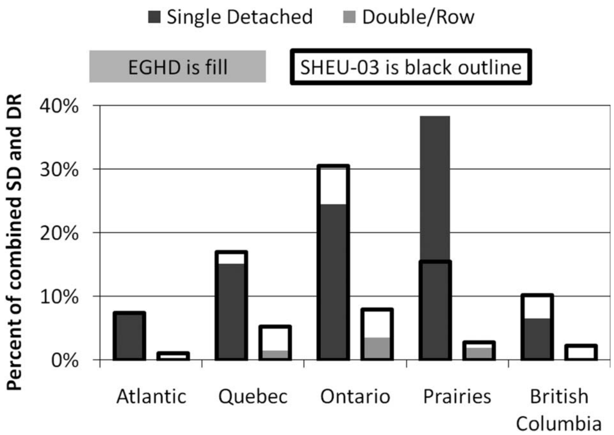

Figure 2. Regional distribution of SD and DR houses in the EGHD dataset and SHEU-03.

Figure 2 shows that in comparison with SHEU-03, the EGHD is lacking DR houses and the SD type is overrepresented in the Prairies region. Aydinalp *et al.* (2001) found different SD distributions, indicative of regional marketing changes of the EnerGuide programme throughout its operating period. This regional analysis by house type shows that the EGHD dataset must undergo significant reduction of overrepresented house records to achieve distributions representative of the CHS, as defined by SHEU-03.

3.2. Selection parameters

Following a review and critical analysis of the data available in SHEU-03, the following 'selection parameter' distributions were chosen as the reference in selecting house files from the EGHD:

- House type (SD or DR)
- Region (Atlantic, Quebec, Ontario, Prairies, British Columbia)
- Vintage (1900–1945, 1946–1969, 1970–1979, 1980–1989, 1990–2003)
- Storeys (one through three including half storeys)
- Living space floor area (25–56, 57–93, 94–139, 140–186, 187–232, 232–300 m^2; excluding basement or crawl space)
- Space heating energy source (electricity, natural gas, oil, wood, propane)
- DHW energy source (electricity, natural gas, oil)

Parameters such as number of occupants and temperature set-points were not used in the selection process as they were typically left as the default value in the EGHD. This was due to the standardized testing protocols of the EnerGuide programme established for comparison purposes.

The SHEU-03 parameter distributions of SD houses are listed on a regional scale and considered reliable; however, due to limited data, SHEU-03 does not consider the regional estimates for DR housing to be reliable. Therefore, in the case of vintage, storeys and living space floor area, the national DR parameter distributions were applied to each region. The regional DR energy source distributions were set equal to the regional SD energy source distributions. These assumptions was considered appropriate due to the more uniform construction of DR dwellings across the nation, and the similar utility and fuel service received by both housing types within a region.

EGHD house records which regionally matched the SHEU-03 selection parameter distributions were selected to form a nationally and regionally representative subset database called the *Canadian Single-Detached and Double/Row Housing Database* (CSDDRD).

3.2.1. *Selection of houses from the EGHD*

The selection of houses for the CSDDRD was accomplished using a forward progressing compare and select/discard algorithm. Prior to the algorithm being invoked, the EGHD was randomly shuffled to remove the influence of chronological or provincially ordered submissions. The algorithm uses two steps: (1) the definition of parameter distributions, and (2) the selection of dwellings.

3.2.1.1. Definition of parameter distributions. The ratio of SD to DR houses defined by SHEU-03 was used to calculate the number of SD and DR houses for the CSDDRD to achieve a desired total of 18,000–20,000 houses. The number of SD houses was set to 15,000. This required 3590 DR house records to maintain a ratio equivalent to SHEU-03, resulting in a total 18,590 desired houses for the CSDDRD.

SHEU-03 specifies the regional distribution of houses by type, which was used to calculate the regional distributions for each selection parameter for the SD and DR houses of the CSDDRD. Table 2 shows the regional distribution for the SD type. It can be seen that the regional distribution of CSDDRD and SHEU-03 houses are equivalent, and that the total number of desired SD houses in the CSDDRD is 15,000.

Using the same approach, the desired number of houses was calculated for each element of the selection parameters, forming arrays. An example parameter is *DHW Energy Source* and its elements are *electricity, oil* and *natural gas* as shown in Table 3. Table 3 shows that the 1381 Atlantic SD houses defined in Table 2 have been distributed by DHW elements equivalent to that specified for the Atlantic region by the SHEU-03 DHW selection parameter.

An organizational chart of the example DHW selection parameter for the Atlantic region is shown in Figure 3. The numerical value is the desired number of houses and the percentage value corresponds to that defined by SHEU-03. There are 50 distinct selection parameter array sets accounting for two house types, five regions and five selection parameters.

3.2.1.2. Dwelling selection. A computer program was written that consecutively progresses through the EGHD dataset, evaluating the parameters of each house record and comparing them to the selection parameter arrays.

If a house record's parameter values matched a desired element for every selection parameter for the appropriate region and house type, the house was added to the subset database and the corresponding element in each parameter array was decremented. As houses continued to be selected, the arrays decremented to zero, limiting any further selection of houses with similar characteristics. This process eliminates the possibility of overrepresenting houses with particular characteristics. If a parameter option was not available (e.g. natural gas in the example of Table 3), or if that option had been decremented to zero by previously selected house records, the house record under review was discarded.

Table 2. SHEU-03 and desired CSDDRD SD house distribution.

Region	SHEU-03	SHEU-03 (%)	CSDDRD	CSDDRD (%)
Atlantic	662,335	9	1381	9
Quebec	1,513,497	21	3157	21
Ontario	2,724,438	38	5683	38
Prairies	1,381,219	19	2881	19
British Columbia	910,051	13	1898	13
Total	7,191,540	100	15,000	100

Table 3. SHEU-03 and desired CSDDRD DHW parameter distribution for the Atlantic region SD house type.

DHW energy source	SHEU-03 (Atlantic)	SHEU-03 (Atlantic) (%)	CSDDRD (Atlantic)	CSDDRD (Atlantic) (%)
Electricity	487,023	76	1043	76
Oil	157,855	24	338	24
Natural gas	0	0	0	0
Total	644,878	100	1381	100

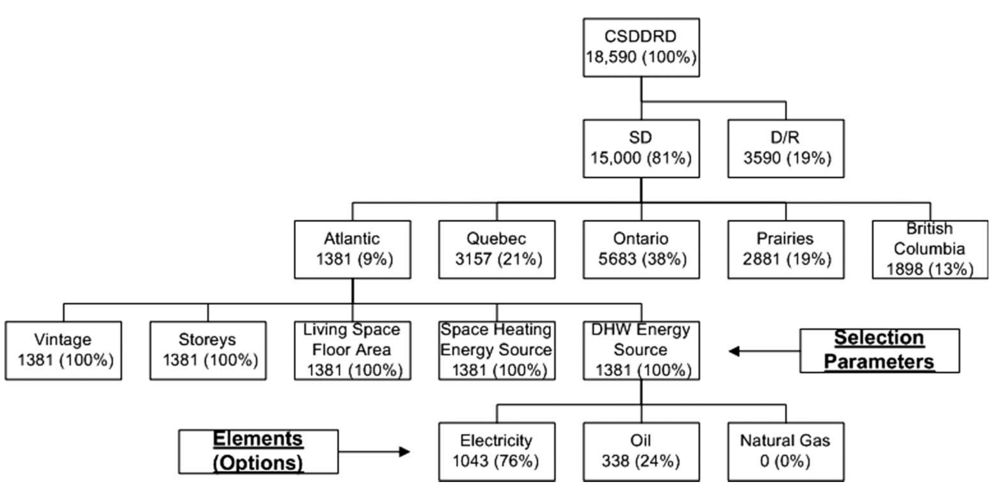

Figure 3. Organizational chart of desired selection parameter array.

The consecutive nature of this technique has a limitation: the first house record encountered in the EGHD dataset which fits with the desired distributions is selected for the CSDDRD. Because of this, a certain popular parameter option may fill, limiting the selection of subsequent house records that have desired characteristics as well as the popular filled characteristic. This was encountered for houses with underrepresented characteristics. Assigning weights to underrepresented houses (i.e. counting each underrepresented house as two or more) was not desirable due to the correlation between house parameters and the reduction of the total number of houses in the CSDDRD. Instead, this problem was addressed by initially sorting the EGHD dataset in such a way that house files with underrepresented parameters were placed at the beginning of the dataset. This forced these records to be encountered first. Although this gives preference to houses with underrepresented characteristics, it does not bias the CSDDRD because the selection parameter arrays limit the inclusion of these houses to the value which is desired.

3.2.2. *Characteristics of the CSDDRD*

A comparison of the regional distributions of the two house types with SHEU-03 is shown in Figure 4. The CSDDRD distribution closely matches with that of SHEU-03. Figure 4 may be compared with the original EGHD dataset distribution shown in Figure 2.

As described, certain parameter options limited the complete fill of the arrays and therefore the CSDDRD has fewer houses than desired. The CSDDRD is comprised of 14,030 SD and 2922 DR house records. This totals 16,952 records which, based on the selection parameters, statistically represent the 8.9 million SD and DR houses of the CHS.

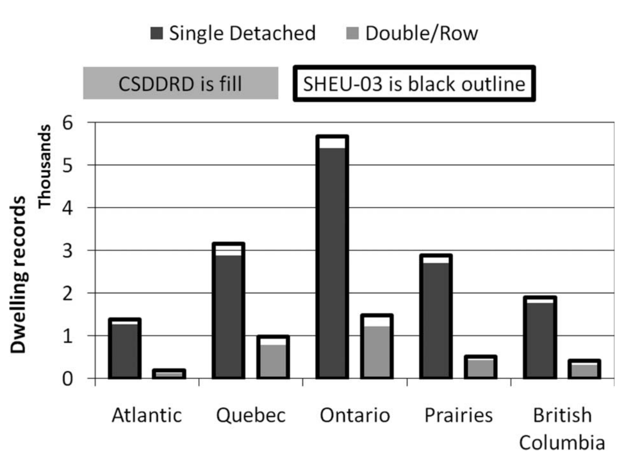

Figure 4. CSDDRD region and house type distributions compared with SHEU-03.

On the basis of the selection parameters, each record of the CSDDRD is of equal weight and represents 525 houses of the CHS. This constant weighting scheme differs from other housing databases such as the SHEU-93 database (Statistics Canada 1993) and the USA 2001 RECS (EIA 2001). The primary reason that representation weights changed for each house in these databases was due to non-responses within the original random sample. Equal weighting among the CSDDRD records eases comparison of energy simulation results and increases resolution for the study of the applicability of technologies that will achieve a low penetration rate.

The CSDDRD maintains the original information fields and structure of the EGHD dataset in a delimited format for use with building energy simulation. The fields of the database correspond to the detailed house generation wizard inputs of the HOT2XP® residential energy analysis software (SBC 2008).

4. Verification and results of the CSDDRD

The CSDDRD is regionally compared with the selection parameters distributions defined by SHEU-03 to identify similarity, indicating good representation of the CHS house types.

The effectiveness of the procedure used to select the houses from the EGHD to populate the CSDDRD is shown in Figures 5–8. Although the distributions of houses in the EGHD dataset with respect to vintage and living space floor area are substantially different than those of SHEU-03 (Figures 5 and 7), the distributions of houses in the CSDDRD match closely with those of SHEU-03 (Figures 6 and 8). These results indicate that the selection process was successful at improving the representation of newer houses (1990 and later) as well as houses with very small and very large floor areas.

Further investigation shows that the distributions of other selection parameters of the CSDDRD, for both SD and DR types, also closely match SHEU-03.

The only selection parameter which did not closely match between the CSDDRD and SHEU-03 was the number of storeys, as shown in Figure 9. This is likely due to a result of two issues: auditor misunderstanding of the half-storey definition and no available option for the imputation of split level houses. This resulted in placement of certain half-storey houses into the two-storey category. As full storeys are the dominant type, this representation issue has limited impact. Figure 9 shows that although houses greater than two storeys existed in the EGHD dataset, none of these houses exist in the CSDDRD because SHEU-03 considers them insignificant.

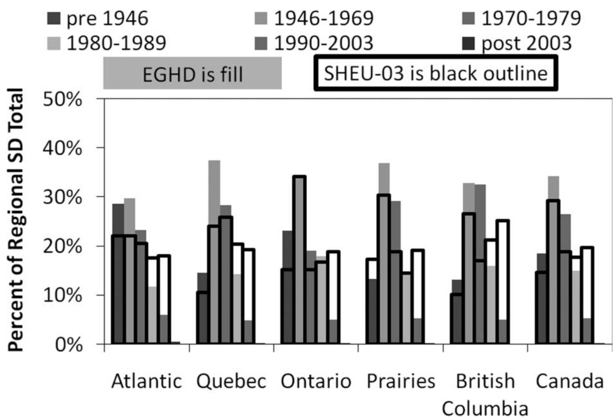

Figure 5. EGHD (SD) vintage distributions compared with SHEU-03.

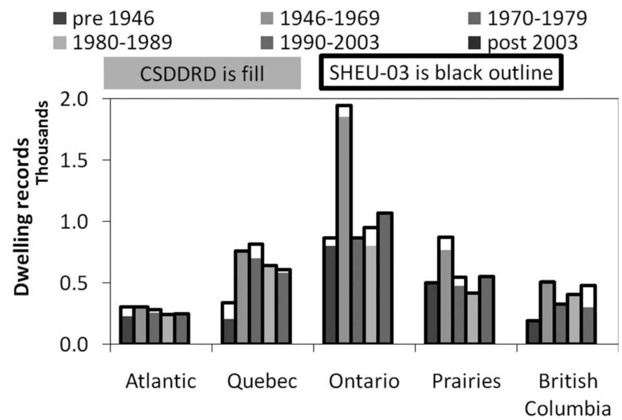

Figure 6. CSDDRD (SD) vintage distributions compared with SHEU-03.

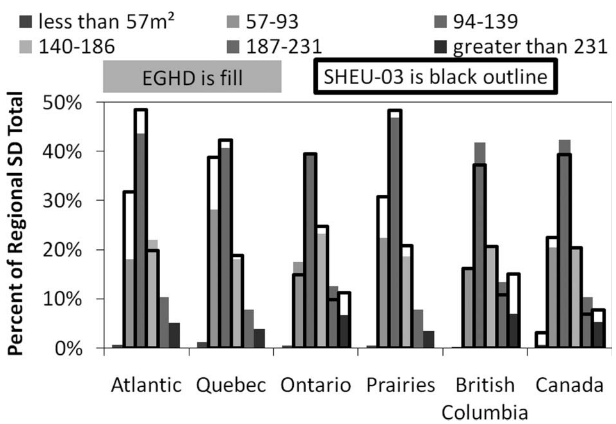

Figure 7. EGHD (SD) living space floor area (excluding basement) distributions compared with SHEU-03.

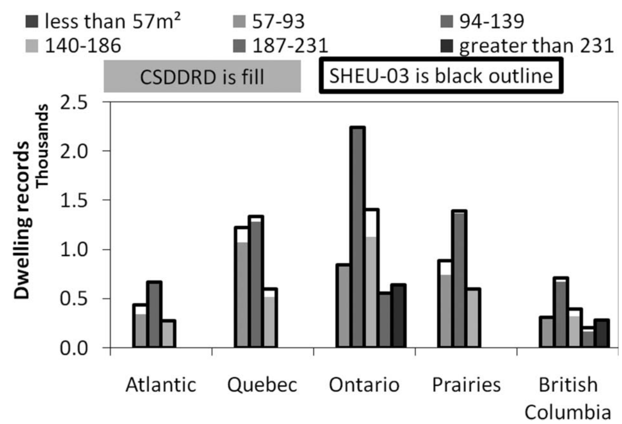

Figure 8. CSDDRD (SD) living space floor area (excluding basement) distributions compared with SHEU-03.

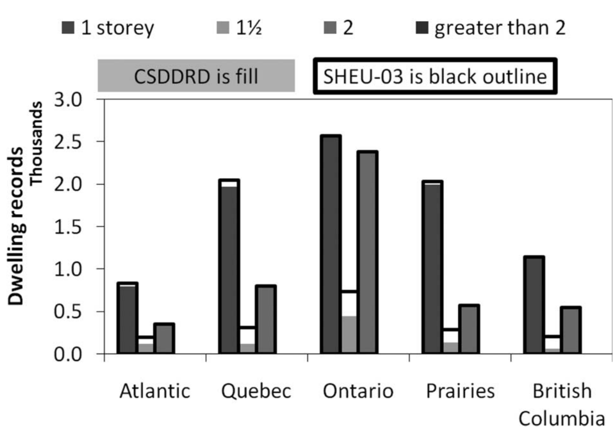

Figure 9. CSDDRD (SD) storeys distributions compared with SHEU-03.

Key characteristics of the CSDDRD are:

- Nationally and regionally representative of both the SD and DR house types of the CHS based on the selection parameters.
- Detailed information on house geometry, construction fabric, infiltration/ventilation and heating systems.
- Inclusion of the wide variety of housing characteristics found in the CHS.
- Individual records which allow for assessment of interrelated characteristics (e.g. insulation levels as a function of region or vintage).
- High resolution level for the assessment of the applicability of alternative technologies.

5. CSDDRD investigation

The characteristics of the CSDDRD allow it to be used as the dataset for energy simulation or interrelation/uptake investigation. A simple investigation of housing trends as a function of vintage and region was conducted for demonstration, and the results are displayed in Table 4. Values of particular parameters of the SD houses were averaged to determine trends within this house type of the CHS.

Table 4. Average CSDDRD (SD) parameter values as a function of vintage and region.

Parameter average	Vintage					Region				
	Pre 1946	1946–1969	1970–1979	1980–1989	1990–2003	Atlantic	Quebec	Ontario	Prairies	British Columbia
Slab presence (%)	1.1	1.9	3.4	3.2	2.8	1.3	1.0	0.9	0.5	13.5
Crawl space presence (%)	9.0	6.2	7.9	7.3	7.5	7.3	6.2	4.1	2.8	26.0
Basement presence (%)	89.9	91.9	88.7	89.5	89.7	91.4	92.8	95	96.7	60.5
Living space floor area (m^2)	126.0	114.8	120.5	150.4	144.8	114.3	109.1	144.7	112.8	149.2
Gross window area (m^2)	19.4	20.3	20.2	23.7	23.5	18.9	19.7	23.1	17.8	25.6
Total number windows	13.5	12.1	11.3	12.9	13.6	12.0	11.3	13.4	11.7	13.9
Average window size (m^2)	1.4	1.7	1.8	1.8	1.8	1.6	1.8	1.7	1.5	1.8
Window of living space wall area (%)	14.2	17.2	16.4	15.6	15.2	15.9	16.8	15.7	14.5	17.4
South facing window to living space floor area (%)	4.4	5.3	5.2	5.1	5.0	5.1	6.0	4.8	4.5	5.1
Ceiling thermal resistance (RSI)	3.8	4.2	4.4	5.1	5.6	4.2	4.6	4.6	5.0	4.4
Living wall thermal resistance (RSI)	1.6	1.8	2.2	2.6	2.9	2.3	2.5	2.1	2.2	2.2
Basement wall; thermal resistance (RSI)	1.6	1.6	1.6	1.9	1.9	1.4	2.1	1.4	1.7	2.5
AC/h at 50 Pa depressurization	10.2	6.9	5.8	5.2	4.4	6.9	6.1	6.5	5.0	8.0
Heat pump presence (%)	1.3	2.5	3.1	2.9	4.0	1.4	6.0	1.8	0.5	5.1
Air conditioner presence (%)	14.5	26.8	23.5	33.2	31.4	0.2	13.7	52.7	10.4	9.3
HRV presence (%)	1.0	3.0	5.5	7.5	20.0	18.7	14.1	5.4	2.4	1.0

Beginning from the foundation of the house, it is apparent that slab and crawl space foundations are a minority compared with basements. Construction rate of slab and crawl space foundations remain stable and are predominant in British Columbia (BC), which experiences a milder climate than most Canadian regions. Although this was not a selection parameter for the CSDDRD, SHEU-03 shows similar results (OEE 2006a).

Living space floor area (excluding basement) of the SD house type has been increasing over the latter half of the twentieth century. It is presently averaging 144 m^2, a value similar to that estimated by the OEE (2006a). Ontario and BC have the largest average areas, which is likely due to increased levels of new construction (see Figure 8).

Window area and count also increased, although to a lesser extent than floor size. Window size has remained nearly constant. Because of this, and the floor area to perimeter relationship, the window to wall area (effective aperture) is decreasing. Windows currently account for 15% of the wall area. The southern facing window area averages 5% of the living space floor area. Parekh and Platts (1990) recommend 8% for passive solar heating in northern climates, based on the thermal storage capacity of typical flooring and the avoidance of overheating. Therefore, it appears that the CHS has significant potential for increased passive solar gain by the addition of southern facing windows, a parameter listed in the CSDDRD.

Thermal resistance has continuously increased, owing to better construction materials/methods and changes in building requirements. Ceiling insulation levels remain approximately twice that of walls. Basement insulation levels are increasing, perhaps due to understanding of ground losses and availability of force/water resistant extruded polystyrene.

Air change rates, as tested using a blower door, steadily decrease with newer construction. It can be seen that on average, for the same pressure difference, newly constructed houses have half the air change rate per hour (AC/h). Chan *et al.* (2005) and Sherman and Dickerhoff (1998) found similar results in US datasets. In Canada, where space heating is a dominant energy consumer of the domestic housing sector (OEE 2006b), this reduction has large impacts. The current R-2000 building standard requires a maximum value of 1.5 AC/h at 50 Pa depressurization (OEE 2005). This is about one-third of the current construction average of 4.4 AC/h at 50 Pa.

Presence of heat pumps, air conditioners and heat recovery ventilation systems (HRV) were evaluated. The penetration rate of these appliances decreases with age, although not to the level expected by technological developments, because of their easy retrofit. Heat pumps have notably higher install rates in hydro-based electrical systems. Occupants in Quebec and BC are accustomed to lower electricity rates as compared with the relatively inexpensive natural gas and a very cold climate which limits heat pump penetration in the Prairies. As expected, air conditioners are predominant in Ontario due to a hot summer climate; however, SHEU-03 estimates a penetration rate closer to 65% (OEE 2006a). Penetration elsewhere is limited. HRV units show significant increases as they are recommended for new SD houses (NRC 1997).

6. Coupling to building performance simulation tools

The high level of detail of each house contained within the CSDDRD allows for its use as the data source for energy simulation. Geometry, roof type, foundation type and orientation provide sufficient information to describe the building shell. Detailed construction codes (typically 10 individual characters) list the exterior and sheathing materials, framing type and size and the insulation layers and interior materials, which are suitable for use with transient heat transfer analysis. The type and placement of windows and doors is listed and can be used for the determination of passive solar gain potential and accounts for these constructions which typically have significantly lower thermal resistance than walls and ceilings. Foundation types and their level and placement of insulation are defined and may be used to simulate the ground and ambient air losses through the foundation. Finally, blower door test results in the form of AC/h at 50 Pa and the effective leakage area at 10 Pa may be used to simulate the air infiltration rate of the dwelling for a variety of wind and temperature conditions. The preceding information may be used to form a detailed thermal envelope description of each dwelling.

The CSDDRD also includes detailed information on the heating, cooling and ventilation systems of each house. The variety of DHW and space heating appliances cover the broad range of equipment found throughout the Canadian residential sector and includes tank-less hot water heaters, heat pumps and condensing furnaces. Air conditioning and ventilation equipment is specified by type and ratings. HRV unit information such as flow-rate and sensible efficiency is listed. These system characteristics may be used to estimate the energy demand and energy consumption by energy source required to meet the needs of the dwelling through building simulation. As the location of the dwelling is listed, the energy simulation may be carried out using weather data from the nearest weather station.

The specific methodology used to couple the CSDDRD to a building performance simulation tool to predict the energy performance of the CHS will be the subject of future companion paper. The CSDDRD itself will be used to identify the regional potential for upgrading the building envelope or HVAC systems, and the installation of alternative or renewable energy technologies. Subsequent simulation of the CSDDRD will be used to assess the impact that such upgrades or technologies have on the energy consumption of the dwelling.

7. Conclusions

By comparison with the recent SHEU-03, a subset of the EGHD has been selected which statistically represents the SD and DR dwelling types of the CHS.

The selected house records, titled the CSDDRD, include nearly 17,000 individual house records with detailed information on geometry, construction fabric, air-tightness, and heating, cooling and ventilation equipment. Each house record is equivalent in weight and represents ~525 actual Canadian houses. The high level of detail and resolution level allow for assessment of the applicability of a wide range of upgrades and new technologies.

The CSDDRD can be coupled to detailed building performance simulation tools to assess the status, trends and applicability for upgrades of the CHS.

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Note

1. Annual hourly energy simulation (engineering type) time is estimated to be 6–12 h using two dual-processor (1.86 Ghz) quad-core computers.

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