ENERGUIDE FOR HOUSES DATABASE – AN INNOVATIVE APPROACH TO TRACK RESIDENTIAL ENERGY EVALUATIONS AND MEASURE BENEFITS

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ABSTRACT

The EnerGuide for Houses (EGH) database is a management information tool and central depository for tracking residential energy evaluations and measuring benefits from the energy evaluations delivered across Canada. The EGH database is a comprehensive computer-based system developed by Natural Resources Canada (NRCan) for the management of its energy efficiency oriented programs.

Energy advisors perform detailed house energy efficiency evaluations and use the energy analysis software to recommend energy efficiency measures to homeowners. The energy analysis software generates a detailed house data file. Once the house evaluation is complete, the energy advisor sends the house data to the EGH database. The EGH database contains an e-mail processor to download the house data from service organizations. This data is subsequently verified and further assembled in a database file. Each data file contains information on the house's physical characteristics and its energy requirements. Information collected in the database can be used by internal program personnel to generate statistics such as the number of house evaluations performed across the country or technical house characteristics data and also assist in making policy decisions.

The database contains files for more than 165,000 houses rated across Canada of which about 26,000 have been re-evaluated after homeowners implemented energy efficiency retrofits. The concepts and database structure allow for the implementation and management of a large-scale energy efficiency program through various delivery channels.

INTRODUCTION

Launched in April 1998, the EnerGuide for Houses program (EGH)[1] is managed by the Office of Energy Efficiency (OEE) at Natural Resources Canada (NRCan). It is part of Canada's response in addressing the global challenge of climate change and specific concerns in the Canadian housing construction and renovation sectors. EGH is a service offered by service organizations across Canada that provides personalized and independent expert advice to homeowners on the energy-efficiency of their homes. The main concepts of EGH are based on the home energy rating system.

An EGH energy advisor investigates the energy-related features of the house and estimates the home's annual energy requirements using the HOT2®[2]XP energy analysis software. It provides a comparative energy efficiency rating and a comprehensive report including recommended retrofits (NRCan 2004d). Once a homeowner implements retrofits, a second EGH evaluation is performed to update the energy efficiency rating. The energy analysis data are supplied to the central depository of the EGH database.

Since October 2003, an incentive grant has been offered to homeowners who implemented energy efficiency measures to improve the energy rating of their home by a certain amount. Since the beginning of the program, 165,000 houses have been evaluated across Canada of which 26,000 houses have been re-evaluated after homeowners implemented energy efficiency retrofits. NRCan forecasts that over 80,000 houses will be evaluated every year for the next five years of which 30 percent of homeowners will apply for a grant after the implementation of the energy retrofits in their home.

The EGH is a massive undertaking and in order to manage and track day-to-day operation, NRCan invested in the development of the EGH database. The main focus of this paper is to describe the components and structure of the EGH database.

MANDATE AND CHALLENGES

The mandate of the EGH program is to promote energy efficiency in existing houses with a target to reduce greenhouse gas emissions (GHGs) by 20 percent, in 20 percent of the housing stock by 2010.

[1] http://www.energuideforhouses.gc.ca/

[2] HOT2 is a registered trademark of Natural Resources Canada

The mandate posed several challenges in the design and conception of the program and its infrastructure. Below are several elements that were considered:

- Efficient methodology and framework allowing service organizations to conduct and transfer several thousand evaluations per month throughout Canada;
- Standardized approach in the delivery of the service and information allowing timely verifications and validation;
- Efficient collection, processing and transfer of information between parties;
- Minimize the administrative activities both for the service organizations and NRCan;
- Allow proactive management and policy decision making; and, more importantly,
- Allow reporting on performance indicators, baseline analysis, information tracking, data gathering and statistical analysis.

The above requirements were addressed with the creation of a comprehensive computer-based system (the "EGH database") that allowed for growth, flexibility, adaptability and sustainability. Over time, it was also expected that other needs would arise and the database would need to meet additional requirements. This came to be important with the announcement of the EnerGuide for Houses Retrofit Incentive (EGHRI) in October 2003 that required a more thorough verification and validation of the data as well as management of the incentive payments.

STRUCTURE OF THE EGH DATABASE

The database contains information on each house with regard to its physical characteristics and energy use. Each submission includes more than 162 information fields. The data includes: location, dimensions, building envelope insulation levels, type of windows and doors, type of heating and hot water systems and their energy efficiencies, energy analysis results, potential recommended upgrades, energy efficiency ratings and so on.

The purpose of the EGH database is to gather the individual energy analysis data. Once an energy advisor successfully completes the evaluation of a house, the resulting energy analysis data is supplied to the EGH database where the information is collected and stored. Energy advisors use HOT2 XP[3] to perform the energy analysis. HOT2 XP has the capability to generate energy analysis results, homeowner reports and also export an ASCII based file with detailed information to provide input data for the EGH database. The EGH database provides NRCan with a tool:

- to track energy efficiency evaluations performed on houses across Canada;
- enable proactive management decisions;
- verify the integrity of the information as a preliminary verification of the evaluations sent by service organizations within NRCan's quality assurance guidelines;
- identify field data errors;
- quantify and tabulate CO_2 reductions/savings (using energy savings calculated by the simulation software); and
- provide a wide variety of reports for statistical and trend analysis.

The system makes use of leading edge software and techniques and has a fully automated import program for evaluation files sent by service organizations via e-mail directly to NRCan's EGH database.

Platform – Programming Languages and Configurations

The EGH database was created using an Oracle database with an OMNIS 7.8 interface. This service-oriented architecture (SOA) represents a structured approach to application development, which results in higher levels of application, maintainability, flexibility and extensibility. The EGH database consists of a C++ Windows 2000 (MS Visual C++ v6) service that answers and acknowledges the transmission of data in compressed (i.e., using an archive utility program such as WinZip) or uncompressed format and an e-mail processor (BOT). The BOT performs verification and data integrity tests before submissions are sent to the Oracle database (Oracle Enterprise Edition release 8.1.6.0.0 and OMNIS 7 version 8).

The current platform and architecture has been tested to determine its capability to handle submissions (RKIL 2002). The test results shown in table 1 indicate that the EGH database can process roughly 5,000,000 submissions yearly. This is more than sufficient since it is expected that only 80,000 evaluations will be conducted and submitted to the EGH database every year.

[3] HOT2 XP – energy analysis software available at no cost at www.buildingsgroup.nrcan.gc.ca

Table 1: Capability of the EGH Database

Component	Capability
Mail listener	275,000 submissions can be read by the system and stored in the in-coming repository awaiting to be processed.
Mail Processor	14,400 submissions can be processed every day by the system.

The EGH database is comprised of three main components (EGH 2004b). These are: the input/output module, the processing module and the reporting module.

Input Module

Upon completion of a house evaluation, house files are e-mailed in a MIME encoded format to the EGH database. Figure 1 shows the flow chart of the input module. A typical e-mail submission contains an energy software specific house data file and a tab-separated variable (TSV) export file. In-coming emails are retrieved by the mail listener and stored in a repository. At that time an e-mail acknowledging receipt of the submission is sent to the originator. Each submission is processed individually for program acceptance. A response is generated and sent to the originator advising whether the submission is accepted, rejected or held for manual review. If the file is rejected, the e-mail response shows the list of possible problems. Information is uploaded to the database for any of the submissions accepted. This includes the individual data elements contained in the tab-separated variable export and the actual files saved as a binary object in Oracle thus allowing users to retrieve them for future reference, simulation and analysis.

Processing Module

The processing module as shown in figure 2 performs verification checks on the status of a submission. These consist of several verifications against pre-determined criteria (EGH 2004a). Below is a summary description of these verifications:

- Verifies that the e-mail submission includes a native and TSV file (data export from HOT2 XP for the EGH Database);
- Determines the type of submission (initial submission "A-file", follow-up submission "B-file", update submission). Depending on the type, different verifications will be performed. In the case of a follow-up submission "B-file", the first verification will consist of validating the housing characteristics against the corresponding initial submission "A-file" to ensure that this is the same dwelling. For an update submission, the first verification consists of validating the update information against the existing file contained in the EGH database;
- Verifies for each TSV that the file naming protocol is valid, the software version used by the service organization is acceptable, the service organization is authorized to conduct and submit energy evaluations, the location of the building corresponds to the postal code and determines the payment classification for the submission. If any of these verifications fail the submission is rejected and the process is terminated. However, if these are successful, a technical assessment is undertaken;
- Verifies the technical content of the submission against archetypes and acceptable ranges (EGH 2004c) defined by program officials. The technical content is comprised of information about the building envelope (size, area and volume, average insulation values for the attic, walls and basement), mechanical systems (heating, domestic hot water and ventilation), air infiltration characteristics (ACH and ELA), results of energy analysis (heat loss by component, energy consumption, energy costs and ventilation requirements) EGH rating, energy upgrades recommended and their potential impact. Table 2 shows examples of acceptable ranges for individual data elements. Over time, verifications have been refined to ensure that specific data elements were within realistic boundaries (i.e. insulation values of ceiling, walls or basement, efficiencies and types of heating and hot water systems);

Table 2: Example of Acceptable Ranges for Individual Data Elements

Data Element	Min Value	Max Value
Footprint	0	600 m^2
Air Changes per Hour @ 50 Pa	0.4	50
Heating Equipment Efficiency for Natural Gas Condensing Systems	88%	96%

Reporting Module

The last component of the database is the reporting module. All submissions can be viewed in the

graphical interface for information and review. The database includes several types of reports. They can be classified as technical reports, management reports, system reports and financial reports. Below is a summary of reports by category:

- Technical reports include: energy analysis results, impact of various retrofit measures, information such as average floor area (example report shown in figure 3);
- Management reports include: Number of acceptable submissions by type (A-file, B-file), energy savings and greenhouse gas emission reductions, opportunity analysis;
- System report includes: number of rejections by type, data element ranges; and
- Financial reports include: number of incentives and value, payment to service organizations.

UTILITY OF EGH DATABASE

Users can conduct more in-depth analysis, simulation, trend analysis and queries. Typical examples are presented here to show the capabilites of the database.

Figure 3 shows a typical vintage based provincial average for energy efficiency ratings and associated average energy consumption for houses. With a sufficiently large number of houses in a specific age group in the database, the average energy consumption data represents well that component of the housing stock.

Figure 4 further show a Canada wide averages for the different age groups of houses. The data shows that, on an average, the annual energy consumption for houses have decreased significantly over the last 60 years. It also shows that houses built in the last 4 years (since year 2000) are about 6.5% more energy efficient than those built during 1990-99.

Figure 5 shows the airtightness and the furnace efficiency of the housing stock. The data shows the progressive improvements in the airtightness of houses as well as the use of better space heating equipment over the years.

The database can also provide various other analyses of insulation levels, ventilation systems, domestic hot water systems and other energy consuming components.

The above exemplifies the utility of the EGH database. The overall analysis results can be used in identifying and targeting specific energy efficiency measures. This will further assist in promoting the energy efficiency goals for Canadians.

Potential Implications for Other Organizations

This information management system is receiving recognition from a wide variety of governmental, not for profit and private sector organizations. This full service business tool could be used to implement a wide variety of initiatives that require the collection and management of a massive amount of information.

By creating a scalable and reliable tool, NRCan has created a Canadian housing data repository as well as an infrastructure that others could use. Several organizations including federal, provincial and utilities are integrating the EGH service into their activities.

CONCLUSION

The EnerGuide for Houses database is an innovative management tool and central depository for NRCan to administer and track residential energy evaluations and to measure benefits from the delivery of energy evaluations across Canada. The database structure allows for growth, flexibility, adaptability and sustainability and enable real-time access to the information for management purposes.

Over time, this database has proven to be a very efficient tool in serving the EGH program's needs. It is a reliable tool, used on a day-to-day basis, essential to the well functioning of the administration of the EGH program.

REFERENCES

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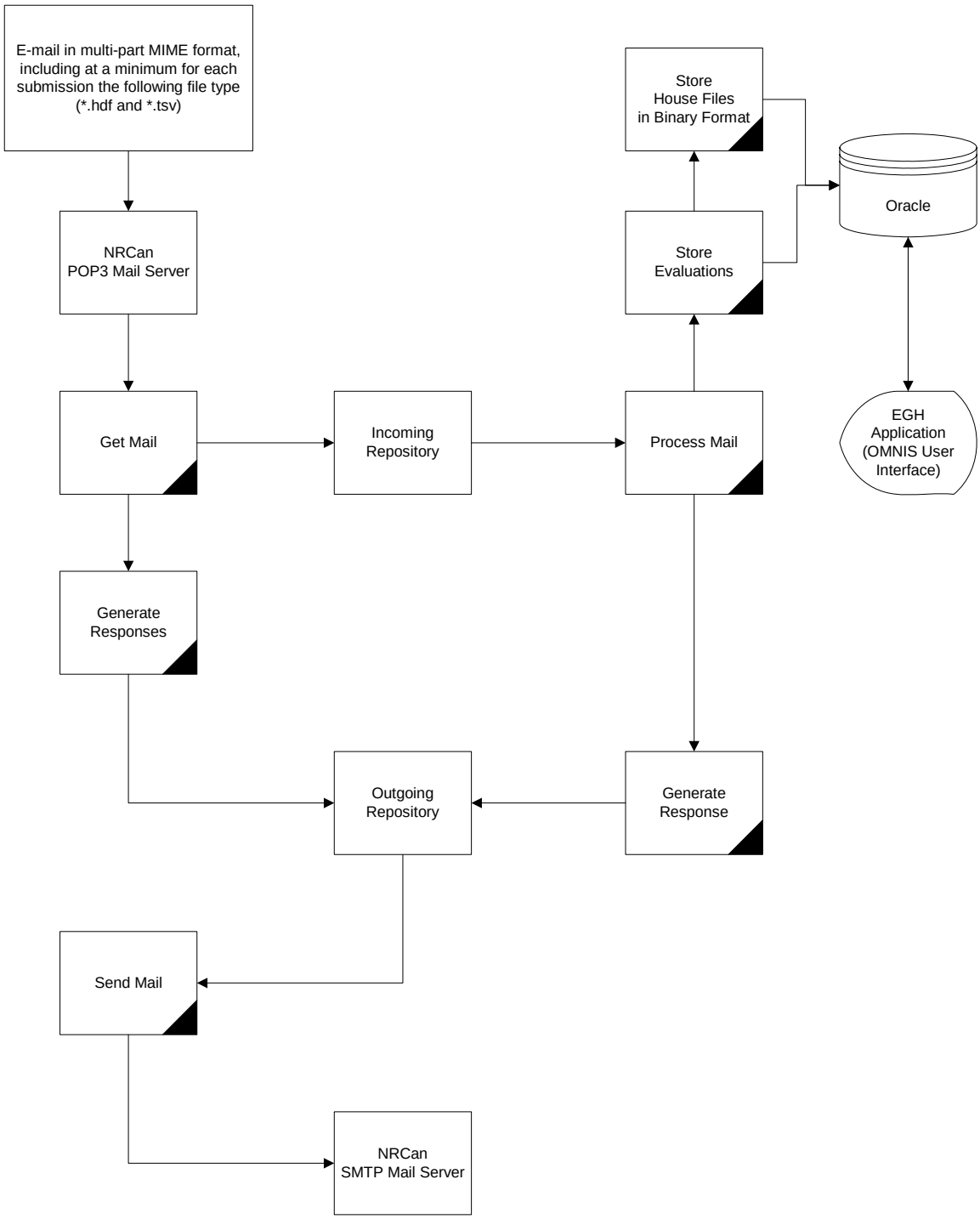


Figure 1: EGH E-mail Flowchart

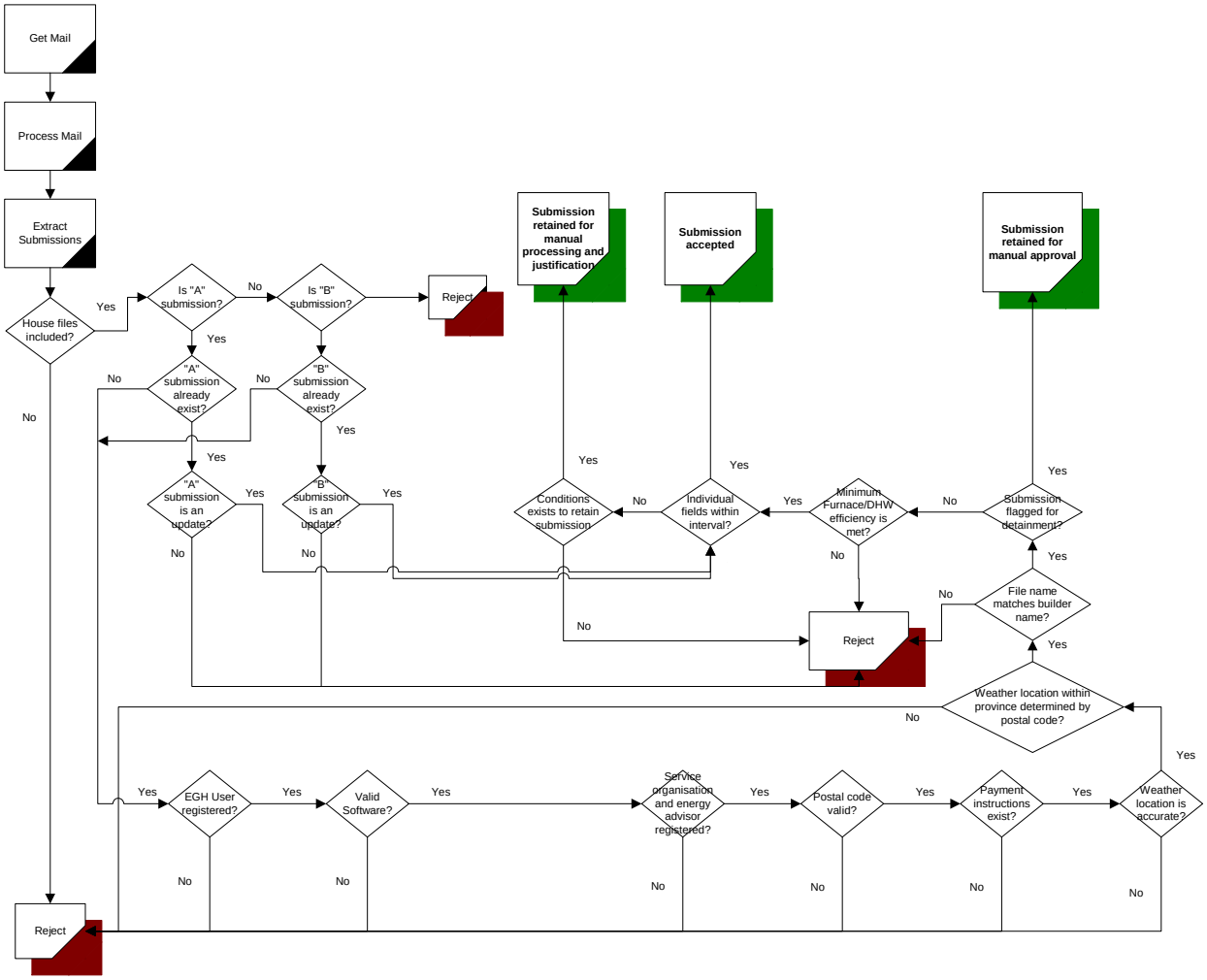
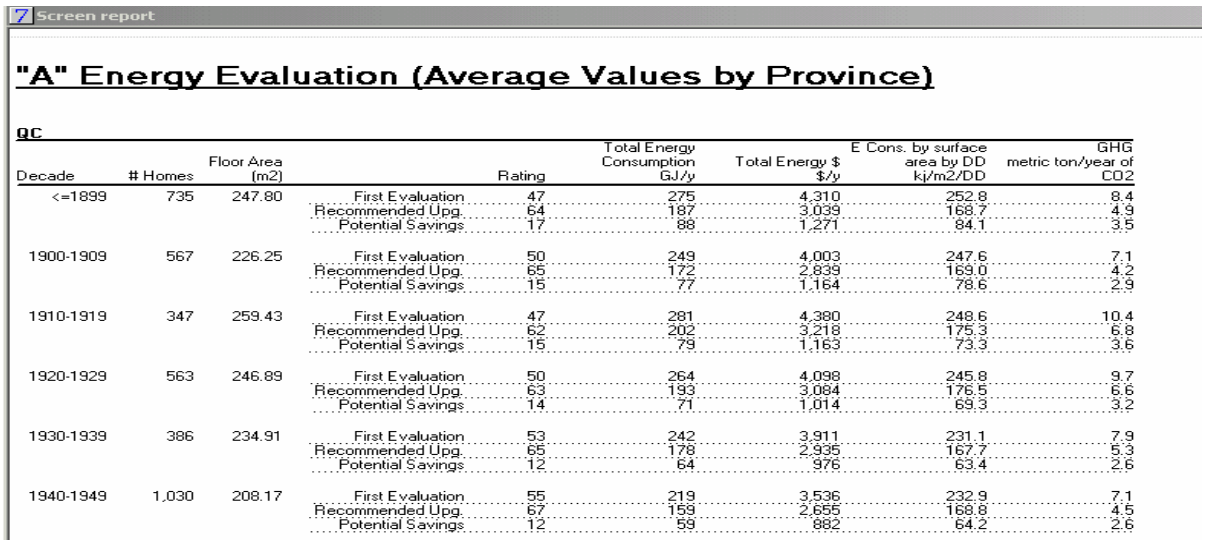


Figure 2: EGH Mail Processor Processes



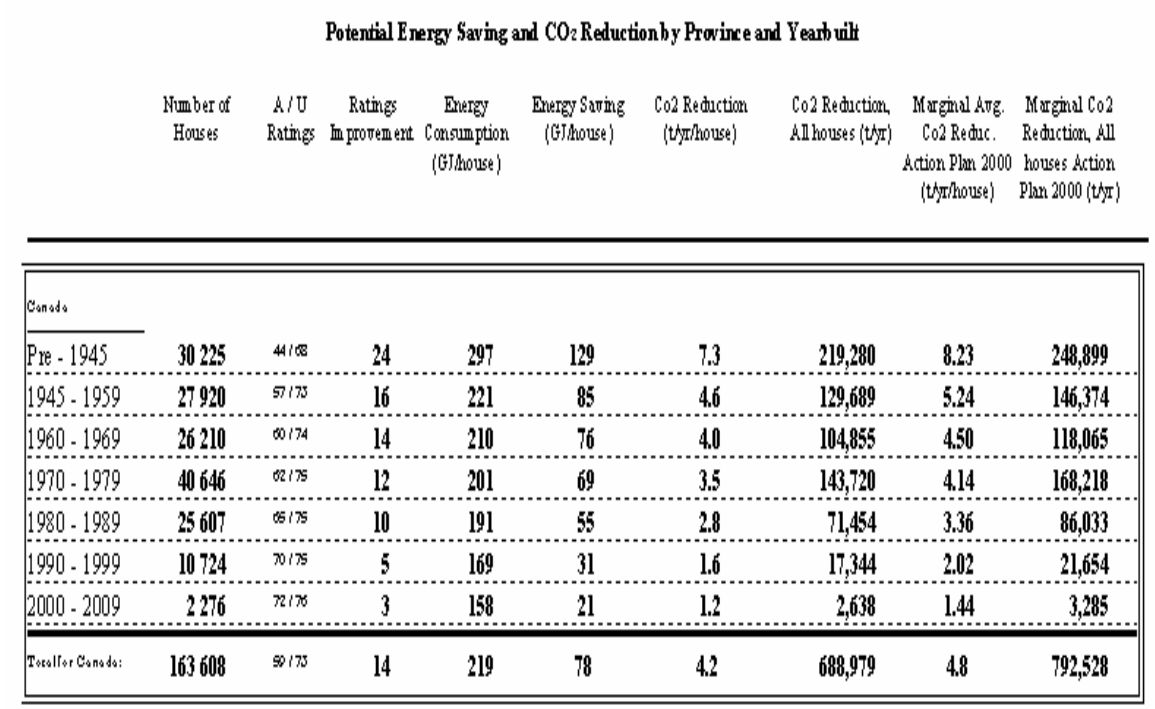
Screen report

"A" Energy Evaluation (Average Values by Province)

QC

Decade	# Homes	Floor Area (m2)		Rating	Total Energy Consumption GJ/y	Total Energy $ $/y	E Cons. by surface area by DD kj/m2/DD	GHG metric ton/year of CO2
<=1899	735	247.80	First Evaluation	47	275	4,310	252.8	8.4
			Recommended Upg.	64	187	3,039	168.7	4.9
			Potential Savings	17	88	1,271	84.1	3.5
1900-1909	567	226.25	First Evaluation	50	249	4,003	247.6	7.1
			Recommended Upg.	65	172	2,839	169.0	4.2
			Potential Savings	15	77	1,164	78.6	2.9
1910-1919	347	259.43	First Evaluation	47	281	4,380	248.6	10.4
			Recommended Upg.	62	202	3,218	175.3	6.8
			Potential Savings	15	79	1,163	73.3	3.6
1920-1929	563	246.89	First Evaluation	50	264	4,098	245.8	9.7
			Recommended Upg.	63	193	3,084	176.5	6.6
			Potential Savings	14	71	1,014	69.3	3.2
1930-1939	386	234.91	First Evaluation	53	242	3,911	231.1	7.9
			Recommended Upg.	65	178	2,935	167.7	5.3
			Potential Savings	12	64	976	63.4	2.6
1940-1949	1,030	208.17	First Evaluation	55	219	3,536	232.9	7.1
			Recommended Upg.	67	159	2,655	168.8	4.5
			Potential Savings	12	59	882	64.2	2.6

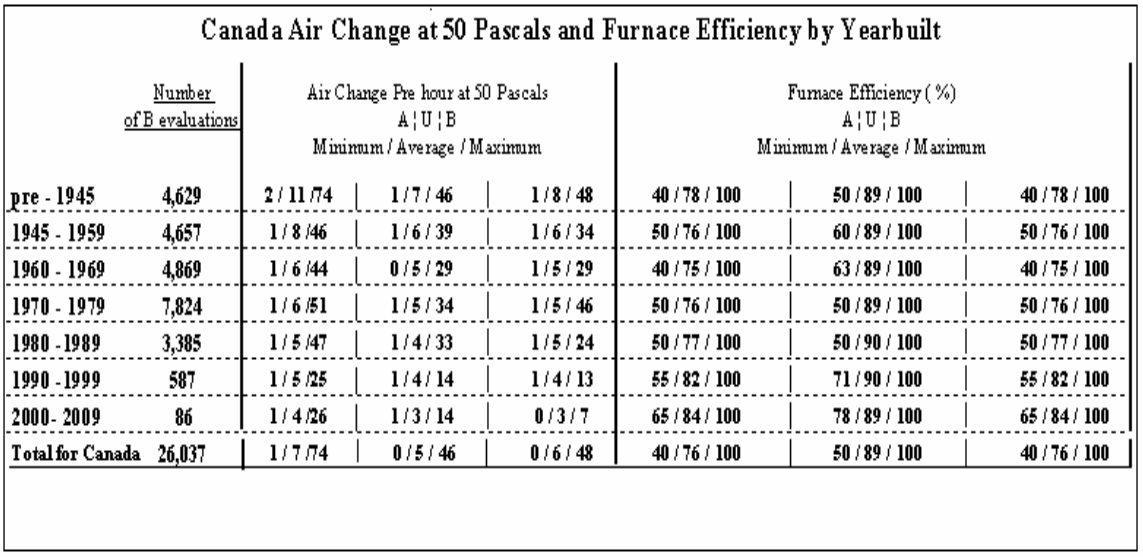
Figure 3: A Typical Example of the Technical Report
(as of May 10th, 2005)



Potential Energy Saving and CO_2 Reduction by Province and Yearbuilt

	Number of Houses	A / U Ratings	Ratings Improvement	Energy Consumption (GJ/house)	Energy Saving (GJ/house)	Co2 Reduction (t/yr/house)	Co2 Reduction, All houses (t/yr)	Marginal Avg. Co2 Reduc. Action Plan 2000 (t/yr/house)	Marginal Co2 Reduction, All houses Action Plan 2000 (t/yr)
Canada									
Pre - 1945	30 225	44 / 68	24	297	129	7.3	219,280	8.23	248,899
1945 - 1959	27 920	57 / 73	16	221	85	4.6	129,689	5.24	146,374
1960 - 1969	26 210	60 / 74	14	210	76	4.0	104,855	4.50	118,065
1970 - 1979	40 646	62 / 75	12	201	69	3.5	143,720	4.14	168,218
1980 - 1989	25 607	66 / 75	10	191	55	2.8	71,454	3.36	86,033
1990 - 1999	10 724	70 / 75	5	169	31	1.6	17,344	2.02	21,654
2000 - 2009	2 276	72 / 76	3	158	21	1.2	2,638	1.44	3,285
Total for Canada:	163 608	59 / 73	14	219	78	4.2	688,979	4.8	792,528

Figure 4: Reporting Potential Energy Savings and CO_2 Reductions (as of May 10th, 2005).



Canada Air Change at 50 Pascals and Furnace Efficiency by Yearbuilt

	Number of B evaluations	Air Change Pre hour at 50 Pascals A¦U¦B Minimum / Average / Maximum			Furnace Efficiency (%) A¦U¦B Minimum / Average / Maximum		
pre - 1945	4,629	2 / 11 /74	1 / 7 / 46	1 / 8 / 48	40 / 78 / 100	50 / 89 / 100	40 / 78 / 100
1945 - 1959	4,657	1 / 8 /46	1 / 6 / 39	1 / 6 / 34	50 / 76 / 100	60 / 89 / 100	50 / 76 / 100
1960 - 1969	4,869	1 / 6 /44	0 / 5 / 29	1 / 5 / 29	40 / 75 / 100	63 / 89 / 100	40 / 75 / 100
1970 - 1979	7,824	1 / 6 /51	1 / 5 / 34	1 / 5 / 46	50 / 76 / 100	50 / 89 / 100	50 / 76 / 100
1980 - 1989	3,385	1 / 5 /47	1 / 4 / 33	1 / 5 / 24	50 / 77 / 100	50 / 90 / 100	50 / 77 / 100
1990 - 1999	587	1 / 5 /25	1 / 4 / 14	1 / 4 / 13	55 / 82 / 100	71 / 90 / 100	55 / 82 / 100
2000 - 2009	86	1 / 4 /26	1 / 3 / 14	0 / 3 / 7	65 / 84 / 100	78 / 89 / 100	65 / 84 / 100
Total for Canada	26,037	1 / 7 /74	0 / 5 / 46	0 / 6 / 48	40 / 76 / 100	50 / 89 / 100	40 / 76 / 100

Figure 5: Evaluation of the Data to Determine Trends for Airtightness and Furnace Efficiency (as of May 10th, 2005)