

**COST AND BENEFIT ANALYSIS
OF PROPOSED CHANGES FOR ENERGY EFFICIENCY IN
HOUSING AND SMALL BUILDING IN THE NATIONAL BUILDING CODE**

**REPORT PREPARED FOR
FRANK LOHMANN, SENIOR TECHNICAL ADVISOR
CANADIAN CODES CENTRE
INSTITUTE FOR RESEARCH IN CONSTRUCTION
NATIONAL RESEARCH COUNCIL OF CANADA**

**BY
GARY PROSKIW, P. Eng.
PROSKIW ENGINEERING Ltd.**

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**SECTION 1
INTRODUCTION**

1.1 INTRODUCTION

This report provides a summary of the cost analysis and benefit analysis carried out for the proposed changes to the National Building Code of Canada (NBCC) for Section 9.36. These proposed changes include detailed specifications for thermal insulation levels, glazing requirements, airtightness and mechanical system performance and represent the first inclusion of designated energy efficiency requirements in the NBCC. To reflect the wide variations in climate which exist across Canada, the proposed Section 9.36. defines six climate zones with specific energy efficiency requirements tailored for each zone.

The objective of the analysis described in this report was to estimate a) the incremental construction costs of the proposed changes and b) the energy savings which these changes would produce for a typical, Canadian new home.

1.2 BENEFIT ANALYSIS

During development of Section 9.36., a validation analysis was carried out to determine the energy performance of a group of representative house designs which complied with the proposed requirements (Proskiw, 2011). Eleven different house designs were used for the analysis. One of these, House #4, was selected for use in the cost and benefit analysis described in this report. This house was judged as the most representative of the 11 designs and was used to estimate the energy savings and associated benefits of the various proposed measures.

Therefore, using House #4 as a representative archetype for the cost and benefit analysis, the annual energy consumption was estimated using an initial set of Base Case conditions (for RSI values, mechanical system efficiencies, etc.) and assuming the house was constructed in each of the six climate zones identified in Section 9.36. The construction specifications for the Base Case house were established using information from a builder survey of current construction practice in the year 2009 in various regions across Canada (Canadian Codes Centre, 2011). It must be noted that the proposed energy efficiency requirements are unique for each of the six climate zones, but that the Base Case house remained relatively similar across all climate zones (see "Base Case Assumptions" below).

As noted above, House #4 was used for the cost and benefit analysis. This house was selected because its annual energy consumption and general performance were judged as the most representative of the 11 Archetypes. As a check, comparisons of the annual energy savings were also prepared for two other houses (#1 and #7) in two zones (Zone #5 and Zone #7a). This

found that the savings in Zone #5 for the two other houses were somewhat greater than for House #4 while in Zone 7a, the savings were quite consistent with those of House #4. Given the normal variation in performance which occurs between houses, these variations were judged as reasonable. Additional information on the representativeness of House #4 is in Appendix A.

Energy modelling was performed using HOT2000, version 10.51 using the same basic protocols employed for the Final Validation.

After the Base Case performance had been established, each of the individual energy efficiency measures described in the proposed Section 9.36. was applied, as applicable, to the Base Case house and the impact on energy consumption calculated. In all cases, except as noted, the measure was applied to the Base Case house in isolation, without any other measures applied so that just the impact of the measure in question could be assessed.

The difference between the Base Case energy consumption and the measure-applied energy consumption represented the energy benefit of the measure. Energy consumption was expressed in kilowatt-hours per year, equivalent (kWh_e/yr) regardless of the energy sources used in the house. The energy consumption was then multiplied by a blended, national energy rate, for all energy sources, of 6 ¢/ kWh_e to arrive at an annual benefit expressed in dollars. This rate, which was developed from a survey of Canadian energy utilities, was used for all locations (Kidd, 2011).

The proposed Section 9.36. establishes separate thermal insulation requirements for a) houses equipped with Heat Recovery Ventilators (HRV's) and b) houses not equipped with HRV's. Generally, houses with HRV's are permitted to have slightly reduced insulation requirements for the building envelope. Consequently, many of the results in this report are shown separately for houses with and without HRV's.

1.3 COST ANALYSIS

To perform the cost analysis, a series of unit construction costs were developed for each of the energy efficiency measures specified in the proposed Section 9.36. For building envelope measures, these were expressed as the cost per unit area of envelope to which the measure was applied (e.g. cost per square metre of exterior wall). Mechanical system measures were typically expressed as a unit cost per item (e.g. dollars per furnace).

These unit costs were developed by Hanscomb Consultants and used Ottawa as the reference city (Hanscomb, 2011). Costs were developed based on the incremental change required for a measure. For example, improvements to attic insulation levels were calculated based on the cost of the proposed measure minus the cost for the Base Case condition.

Hanscomb then applied a series of location modifiers to the Ottawa data to describe the variation in construction costs for the six locations used in the cost analysis. These modifiers ranged from 1.00 in Toronto and Montreal to 1.38 in Yellowknife. Also note that in Zone 7b, Edmonton was used for the cost analysis while Fort McMurray was used for the energy analysis

(due to the lack of construction cost data for Fort McMurray). Details concerning the locations used for the cost analysis and the benefit analysis are shown Table 1. Some other key assumptions used for the cost analysis are summarized below:

Costs - All labour and materials included.

Cost Base - All costs shown are retail costs (what the consumer would pay) and were based on July, 2011 dollars using Ottawa as the baseline, with adjustments for regional modifiers.

Cost Escalation - None beyond July, 2011.

Taxes - Neither GST or HST included.

Contractors Discount - None included.

Delivery Charges - None included.

Table 1
Representative Locations Used In The Cost-Benefit Analysis

Cost		Benefit (Energy Savings)		
Location	Factor	Location	Zone	Heating Degree Days
Ottawa (reference)	1.00			
Halifax	0.95			
Vancouver	1.10	Vancouver	4	<3000
Toronto	1.00	Toronto	5	3000 to 3999
Montreal	1.00	Montreal	6	4000 to 4999
Winnipeg	1.08	Winnipeg	7a	5000 to 5999
Edmonton	1.12	Fort McMurray	7b	6000 to 6999
Yellowknife	1.38	Yellowknife	8	≥7000

Note: While these locations were chosen primarily because they offered good representation of a specific climate zone, the analysis in this report does not replace a regional cost-benefit analysis for these locations.

1.4 BASE CASE ASSUMPTIONS

The main energy-related variables (RSI values, etc.) used in the Base Case house for the energy analysis are summarized in Tables 2 and 3. These were obtained from the "Summary of Current Construction Practice" prepared for the Canadian Commission on Building and Fire Codes. However, it is important to remember that, with the exception of airtightness, the same energy-related design values were used in all six climate zones. Region-specific, airtightness values were used because the airtightness of new houses is known to vary significantly across

the country and because the information was available. Airtightness values used for the Base Case house are provided in Table 4.

Notice that Table 2 shows thermal insulation levels as both the effective RSI value (RSI_{eff}), since this is how they are expressed in Section 9.36., as well as the nominal, equivalent R-value.

1.5 OTHER BENEFITS

This benefit analysis was concerned solely with energy benefits. No allowance was made for other benefits which the proposed measures would provide such as improved building durability (due to reduced moisture transport into the envelope caused by air leakage), improved comfort, better health (due to reduced condensation issues), etc. - even though these can be substantial.

**Table 2
Summary Of Key Energy Efficiency Variables Used For The Base Case House**

Building Feature	Current Practice	
Wall insulation	RSI_{eff} 2.93	R-20 nominal
Attic insulation	RSI_{eff} 7.04	R-40 nominal
Basement insulation, walls	RSI_{eff} 1.82, Full height	R-12 nominal, Full height
Basement insulation, floor slabs	Uninsulated	Uninsulated
Rooms over unheated spaces	RSI_{eff} 4.94	R-28 nominal
Windows	Double-glazed, Low-E, argon fill, insulated spacers, vinyl frame. U-value = 1.8	
Doors	Insulated steel door RSI 1.14	Insulated steel door R-6.5
Heating system type and efficiency Gas Electric Oil	90%, forced air 100%, forced air 75%, forced air	
DHW system efficiency Gas Electric	55% 82%	
Ventilation system	Mechanical ventilation provided, but without heat recovery	
Air conditioning	No air-conditioning	
Heat pumps	No heat pumps	

Table 3
Description of House #4

House Type	Two storey, detached house with full basement
Construction	Wood frame construction with a cast-in-place basement
Floor area (based on interior dimensions) - Main and second floor - Main and second floors, and basement	153.8 m ² 230.3 m ²
Window area - Picture windows - Hinged windows - Slider windows - Total window area	14.74 m ² (48%) 13.93 m ² (45%) <u>2.22 m² (7%)</u> 30.89 m ²
FDWR (fenestration / door-to-wall ratio) ¹	15%
Volume (based on interior dimensions)	596 m ³
Heating system	Forced air furnace with natural gas, electricity or oil heating (depending on location)
Domestic Hot Water system	151 L tank with natural gas or electricity heating (depending on location)
Ventilation system	Mechanical ventilation system operating 8 hours per day

1. FDWR = $\frac{A_{DW}}{(A_w + A_f)}$

where: A_{DW} = gross door and window area (main and second floors, and basement)
 A_w = gross wall area on the main and second floors (including headers)
 A_f = gross, above-grade foundation wall area

Table 4
Regional Airtightness Levels Used In The Analyses

Zone	Heating Degree-Days	Representative Location	Airtightness (ac/hr ₅₀)
4	< 3000	British Columbia	3.80
5	3000 to 3999	Ontario	3.20
6	4000 to 4999	Quebec	3.10
7a	5000 to 5999	Manitoba	2.30
7b	6000 to 6999	Alberta	3.40
8	≥ 7000	Northwest Territories	4.00

1.6 FURTHER INFORMATION

This report summarizes the costs and benefits of the most significant measures in the proposed Section 9.36. requirements. However, it does not address all of the proposed measures because some were not applicable to the archetype house used to conduct the analysis. Information on the costs and benefits of these measures is contained in spreadsheets developed for this project. Since it is anticipated that most readers will access this report electronically, they should also access the spreadsheets for more detailed information.

1.7 General Clarification

This cost benefit analysis was completed as an exercise to obtain an indication of the energy impact of the proposed changes on a national base. Although specific locations were used in the analysis, this cost-benefit study cannot be taken as a true reflection of the cost or energy savings for those locations.

The exercise investigated the impact of the changes based on the six climate zones. The locations representing each climate zone were chosen primarily for their climate data. The costing information was developed for the same or similar (close by) areas. The energy savings were calculated using a blended energy rate based on utilities (gas and electricity) from major Canadian metropolitan areas.

The baseline for energy performance calculations was established as a single Canada-wide baseline, established from a builder survey in 2009. This survey took into account all Canadian provinces and their respective construction practices. The outcome was an average baseline that accounted for provinces that already have energy efficiency code provisions, as well as those who do not.

While there could be small differences in the climatic profile of other Canadian locations that fall in the same climate zone, for instance solar gain, there might be large differences between different Canadian regions, when it comes to the cost of construction materials or the current construction practice.

In order to achieve a true representation of the impact of the proposed requirements in a specific region, it would be paramount that the analysis be performed using the respective regional context of current construction baseline, cost of construction materials and utility rates as well as common housing archetypes. The energy target data could then be used to calculate the benefits for an actual region.

**SECTION 2
BUILDING ENVELOPE**

2.1 ABOVE-GROUND ASSEMBLIES

Depending on the climate zone, the proposed requirements call for various levels of increased attic and main wall insulation with respect to the construction baseline - the only exception being Zone 4. Overall, the costs and benefits attributable to these two measures were fairly modest, representing roughly 10% of the total incremental cost of complying with Section 9.36. and producing about 10% of the total energy savings.

Tables 5 and 6 show the costs and energy benefits of the higher attic insulation levels in the proposed measures, for houses with and without an HRV. Both the costs and energy benefits are expressed per unit of component (attic) area and were developed using House #4 which has an attic area of 78.8 m².

Tables 7 and 8 show the costs and energy benefits of the higher exterior wall insulation levels, expressed per unit of wall area, with and without an HRV. Again, the costs and energy benefits are expressed per unit of component (exterior wall) area and were developed using House #4 with an exterior wall area of 133.5 m².

**Table 5
Attics, Costs and Benefits Per Unit Attic Area (Houses Without HRV)**

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	\$2.14	\$2.14	\$4.62	\$4.79	\$5.90
Benefit (kWh _e /yr•m ²)	Same as Base Case	1.12	1.14	2.97	3.36	5.29

**Table 6
Attics, Costs and Benefits Per Unit Attic Area (Houses With HRV)**

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	Same as Base Case	\$2.14	\$2.31	\$4.79	\$5.90
Benefit (kWh _e /yr•m ²)	Same as Base Case	Same as Base Case	1.14	1.59	3.36	5.29

Table 7
Walls, Costs and Benefits Per Unit Wall Area (Houses Without HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	\$3.39	\$3.39	\$3.66	\$15.69	\$19.33
Benefit (kWh _e /yr•m ²)	Same as Base Case	4.19	4.29	5.89	18.38	29.46

Table 8
Walls, Costs and Benefits Per Unit Wall Area (Houses With HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	\$2.51	\$2.51	\$2.71	\$3.79	\$4.67
Benefit (kWh _e /yr•m ²)	Same as Base Case	2.64	2.72	3.72	6.02	9.70

2.2 WINDOWS, DOORS AND SKYLIGHTS

Since the proposed window requirements are the same for houses with HRV's and without, the costs and benefits for both scenarios are the same, as shown in Table 9 using House #4 with a window area of 30.95 m². Only the windows in Archetype House #4 were altered, the doors remained unchanged and the house did not have any skylights.

As is typical in energy cost/benefit studies of this type, window costs were a relatively large portion of the total incremental costs. For the four climate zones in which the windows were improved, their cost represented about one-quarter to one-half of the total incremental cost for House #4 (including building envelope and mechanical system costs). The corresponding benefits varied from 21% to 36% of the total energy savings.

Table 9
Windows, Costs and Benefits Per Unit Window Area (Houses With or Without HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	Same as Base Case	\$83.74	\$90.44	\$129.72	\$159.84
Benefit (kWh _e /yr•m ²)	Same as Base Case	Same as Base Case	38.87	53.34	70.66	125.17

2.3 BELOW-GRADE ASSEMBLIES

The proposed changes require higher insulation levels for the foundation walls (all zones) and the basement floor slab in Zone 8. Costs and benefits for the foundation walls, developed using House #4 with a basement wall area of 87.7 m² are shown in Tables 10 and 11. Costs and benefits for the floor slab, with an area of 76.5 m² are given in Table 12. Underslab insulation was required in Zone 8 since it contains areas of permafrost.

Table 10
Basement Walls, Costs and Benefits Per Unit Basement Wall Area (Houses Without HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	\$3.41	\$2.90	\$2.90	\$4.71	\$4.89	\$6.02
Benefit (kWh _e /yr•m ²)	1.36	8.81	9.52	15.29	16.10	37.86

Table 11
Basement Walls, Costs and Benefits Per Unit Basement Wall Area (Houses With HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	3.41	\$2.90	\$2.90	\$3.13	\$3.25	\$4.00
Benefit (kWh _e /yr•m ²)	1.36	8.81	9.52	12.45	13.15	25.78

Table 12
Basement Floors, Costs and Benefits Per Unit Basement Floor Area
(Houses With or Without HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$/m ²)	Same as Base Case	Same as Base Case	Same as Base Case	Same as Base Case	Same as Base Case	\$69.00
Benefit (kWh _e /yr•m ²)	Same as Base Case	Same as Base Case	Same as Base Case	Same as Base Case	Same as Base Case	15.90

2.4 AIRTIGHTNESS

The proposed changes require compliance with a number of prescriptive air sealing details. These details were assumed to produce an airtightness of 2.5 air changes per hour at a pressure differential of 50 Pascals (ac/hr₅₀). However, airtightness levels are known to vary across the country. The "Summary of Current Construction Practice" drew upon a recent, large survey by Natural Resources Canada (NRCan) of airtightness in houses less than five years old. While the average, national airtightness level in this study was 3.18 ac/hr₅₀, the specific regional values from the study - summarized in Table 4 - were used in the Cost and Benefit analyses.

Due to the variation in airtightness levels, estimating the costs and benefits of improved sealing proved somewhat more problematic than other measures. Eventually, the following analysis methodology was developed. First, it was noted that the measured levels in Table 4 ranged from 2.30 ac/hr₅₀ to 4.00 ac/hr₅₀. Although the proposed Section 9.36. does not define a target airtightness level, nor does it require testing of the house, it does identify a series of 11 specific measures aimed at sealing specific parts of the building envelope. Further, in the development of Section 9.36. it was assumed that application of all 11 measures would produce an airtightness of 2.50 ac/hr₅₀. Therefore, the energy benefits in a particular location were estimated by comparing the house's energy consumption at the airtightness level shown in Table 4 versus that which would occur at 2.50 ac/hr₅₀.

The corresponding costs were estimated by first calculating the total cost of applying all 11 sealing measures (which are size-dependent) to the Base Case house. Then, the cost of existing air sealing measures (which are already required by the National Building Code) was subtracted from this value. The cost of these existing measures was generally about one-quarter the cost of all 11 measures. The resultant cost was then pro-rated based on how much the airtightness had to be improved from the values shown in Table 4 down to 2.50 ac/hr₅₀, versus how much it would have to be improved to go from an assumed worst case airtightness of 6.70 ac/hr₅₀ to 2.50 ac/hr₅₀, as shown in Eqn. (1). The value of 6.70 ac/hr₅₀ was selected from NRCan's study and was felt to represent a house which has received little, if any, attempts at air leakage sealing.

$$\text{Net Airtightness Cost} = (\text{Cost, 11} - \text{Cost, existing}) \times (A - B) / (C - B) \quad (1)$$

where:

Cost, 11 = cost of the 11 airtightness measures identified in Section 9.36.

Cost, existing = cost of the existing airtightness measures currently required

A = airtightness from Table 4,

B = assumed final airtightness, 2.50 ac/hr₅₀

C = worst case airtightness, 6.70 ac/hr₅₀

In the case of Zone 7a, whose average airtightness was 2.30 ac/hr₅₀ (which is better than the assumed final airtightness), it was argued that the proposed airtightness requirements would impose zero cost and produce zero benefit.

The resultant costs and benefits of improved airtightness are summarized in Table 13, for both houses without HRV's and houses with HRV's.

The average airtightness of the six zones was 3.30 ac/hr₅₀ while the average cost to reduce the leakage down to 2.50 ac/hr₅₀ was \$360. If this data is weighted by population, then the average, weighted airtightness was 2.99 ac/hr₅₀ while the average, weighted incremental cost was \$204.

Table 13
Airtightness, Costs and Benefits (Houses With or Without HRV)

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$)	\$535	\$267	\$216	\$0	\$369	\$772
Benefit (kWh _e /yr)	266	184	242	0	1321	6469

Considerable variation was observed in the results, particularly for the energy benefits. This was largely due to the wide variations in observed airtightness plus the significant climate differences across the six zones. For example, Zone 8 had the leakiest reported houses and also has the most severe climate which maximizes the stack effect - the primary driver of air infiltration in houses.

**SECTION 3
HEATING, VENTILATION AND AIR-CONDITIONING**

3.1 MECHANICAL SYSTEMS

Some of the key results for the heating, ventilation and domestic hot water heating systems are discussed below. Additional information on the costs and benefits of other mechanical system measures is available in the attached spreadsheets.

3.2 HEATING SYSTEMS

The costs and benefits of the furnace measures are shown in Table 14. Note that Zone 6 was modelled with an electric furnace for all cases so no costs or benefits were encountered while Zone 8 used oil heating. All other zones were modelled with natural gas, furnaces. The proposed requirements for heating systems call for a minimum Annual Fuel Utilization Efficiency (AFUE) of 92% for natural gas furnaces and 85% for oil furnaces. Since electric furnaces operate at 100% efficiency, no additional requirements are included.

**Table 14
Furnaces, Costs and Benefits (Houses With or Without HRV)**

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Fuel	Gas	Gas	Electric	Gas	Gas	Oil
Costs (\$)	\$286	\$260	Same as Base Case	\$281	\$291	\$1435
Benefit (kWh _e /yr)	120	200	Same as Base Case	319	401	2522

3.3 VENTILATION SYSTEMS

Table 15 summarizes the costs and benefits of Heat Recovery Ventilators in each of the six climate zones. Although HRV's are not required by the proposed Section 9.36., houses which do have them are allowed to use slightly reduced insulation levels. The analysis found that while the costs for HRV's remained relatively similar for all locations (which the possible exception of Zone 8), significant variation was observed for the benefits - which ranged from a maximum of 575 kWh_e/yr to a low of 8 kWh_e/yr. The latter figure may appear surprising especially since it occurred in the coldest of the six climate zones. This issue is discussed in more detail in Section 4, but basically the reason for the near-negligible benefits of HRV's in Zone 8 is that even though the house's airtightness was modelled at 2.5 ac/hr₅₀ (versus 4.0 ac/hr₅₀ for the Base Case), natural infiltration was still able to provide almost all of the required ventilation. This occurs because the primary driver for natural infiltration is the stack effect whose magnitude depends on the indoor-to-outdoor temperature differential. The larger the temperature differential - the greater the natural infiltration. As a result, only a very small

amount of mechanical ventilation is required in Zone 8, assuming an airtightness of 2.5 ac/hr₅₀. Since an HRV can only recover energy from that portion of the total air change rate which occurs through the ventilation system, the benefits of the HRV become almost negligible. If the building envelope were leakier, the benefits of the HRV would be even further eroded while if the envelope were made tighter, the benefits of an HRV would be improved.

**Table 15
HRVs, Costs and Benefits**

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Costs (\$)	\$1760	\$1600	\$1600	\$1728	\$1792	\$2208
Benefit (kWh _e /yr)	339	575	507	552	520	8

3.4 DOMESTIC HOT WATER HEATING SYSTEMS

The proposed requirements for DHW systems mainly impact the choice of hot water heater used in the house. Natural gas water heaters are required to have a minimum Energy Factor (EF) of 0.62 while electric water heaters must have a minimum EF of 90%.

**Table 16
DHW Tanks, Costs and Benefits, (Houses With or Without HRV)**

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
	<3000	3000 to 3999	4000 to 4999	5000 to 5999	6000 to 6999	>7000
Fuel	Gas	Gas	Electric	Electric	Gas	Electric
Costs (\$)	\$483	\$439	\$175	\$189	\$492	\$242
Benefit (kWh _e /yr)	558	564	277	245	632	173

SECTION 4 WHOLE HOUSE IMPACT

4.1 IMPACT ON WHOLE HOUSE BASIS

The previous sections of this report have dealt with the costs and benefits of individual measures applied, in isolation, to House #4. This section addresses the overall costs and corresponding benefits of applying Section 9.36. to a typical, new Canadian home as represented by House #4. As such, it does not include all measures identified in Section 9.36., only those which are applicable to House #4. The results are summarized in Tables 17 and 18.

The approximate population weight used to calculate the weighted averages in Tables 17 and 18 was determined based on the population of 24 Canadian Metropolitan areas and their respective populations. This represents about 57% of the Canadian population.

Since many of the proposed measures in Section 9.36. only apply in a small or very small percentage of houses (for example, covers for indoor swimming pools), they were not included in the whole house analysis involving House #4. However, the attached spreadsheets contain the estimated costs and energy benefits of these measures. This information can be used to evaluate the impact of such measures on an individual house. If a broader, country-wide assessment is desired, then the impacts described in this report can still be used provided they are multiplied with a suitable "utilization factor" which identifies the percentage of new, Canadian homes which would benefit from the measure.

Table 17
Summary of Whole House Costs and Benefits, Houses Without HRV

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
Weight for this climate zone (by Population)	11%	28%	30%	31%	0.04%	0.05%
Building Envelope						
Cost (\$)	\$834	\$1,142	\$3,683	\$4,065	\$7,286	\$14,572
Savings (kWhe)	385	1604	2944	4014	7640	19233
Mechanical						
Cost (\$)	\$862	\$784	\$260	\$548	\$878	\$1,728
Savings (kWhe)	745	836	336	625	1085	2713
Whole House Summary (House #4)						
Base Case Consumption (kWhe)	24630	30232	29588	36512	43388	66466
Energy Savings (kWhe)	1130	2440	3280	4639	8725	21946
Energy reduction (House #4)	4.6%	8.1%	11.1%	12.7%	20.1%	32.9%
Cost	\$1,697	\$1,926	\$3,943	\$4,613	\$8,164	\$16,299
Benefit	\$68	\$146	\$197	\$278	\$524	\$1,317

	Average	
	not weighted	weighted
Consumption (kWhe/yr)	38499	31420
Savings (kWhe/yr)	7027	3244
% reduction	18%	10%
Cost	\$6,107	\$ 3,350
Benefit	\$425	\$196

Blended rate	
\$/kwh	\$/MJ
\$ 0.06	\$ 0.02

Table 18
Summary of Costs and Benefits, Houses With HRV

	Zone 4	Zone 5	Zone 6	Zone 7a	Zone 7b	Zone 8
Weight for this climate zone (by Population)	11%	28%	30%	31%	0.04%	0.05%
Building Envelope						
Cost (\$)	\$834	\$856	\$3,565	\$3,618	\$5,553	\$12,437
Savings (kWhe)	385	1310	2944	3366	5731	15563
Mechanical						
Cost (\$)	\$2,622	\$2,384	\$1,860	\$2,276	\$2,670	\$3,936
Savings (kWhe)	1084	1,411	843	1177	1605	2720
Whole House Summary (House #4)						
Base Case Consumption (kWhe)	24630	30232	29588	36512	43388	66466
Energy Savings (kWhe)	1469	2721	3787	4543	7336	18283
Energy reduction (House #4)	6.0%	9.0%	12.8%	12.4%	16.9%	27.5%
Cost	\$3,457	\$3,240	\$5,425	\$5,893	\$8,223	\$16,373
Benefit	\$88	\$163	\$227	\$273	\$440	\$1,097

	Average	
	not weighted	weighted
Consumption (kWhe/yr)	38469	31420
Savings (kWhe/yr)	6357	3480
% reduction	17%	11%
Cost	\$7,102	\$4,753
Benefit	\$384	\$210

Blended rate	
\$/kwh	\$/MJ
\$ 0.06	\$ 0.02

4.2 THE COST OF THE PROPOSED SECTION 9.36. MEASURES AND THE COST OF HOUSING

As shown in Table 19, the estimated, average, population-weighted cost of the proposed Section 9.36. measures ranged from \$3350 (no HRV) to \$4753 (HRV). To put this into perspective, the average selling price of a new home (including land) in large urban centres in Canada was \$356,223 in December, 2009 (CMHC, 2011). Within metropolitan areas, the average selling price was \$550,317. Therefore, the percentage increase of the proposed Section 9.36. measures ranges from 0.6% to 1.3% of the selling price of a new home in Canada.

**Table 19
Percent Cost Increases Due To Proposed Section 9.36. Requirements**

Average Selling Price	Houses Without HRV (Average, Population-Weighted Incremental Cost = \$3350)	Houses With HRV (Average, Population-Weighted Incremental Cost = \$4753)
Large urban centres (\$356,223)	0.9%	1.3%
Total metropolitan areas (\$550,317)	0.6%	0.9%

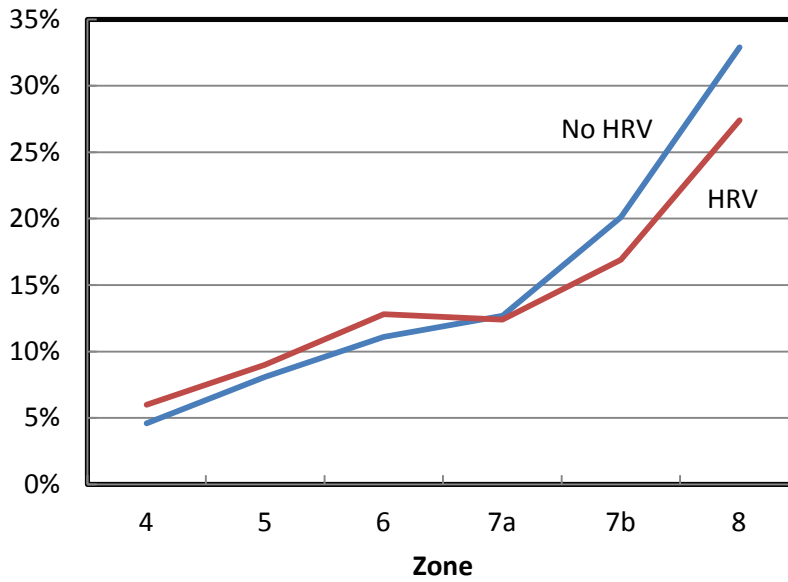
4.3 CONCLUDING REMARKS ON THE ENERGY BENEFITS OF SECTION 9.36.

Figure 1 shows the percentage savings for House #4, for all six climate zones, when designed using the HRV pathway and the No HRV pathway. Several comments can be made.

First, the savings for both pathways increase as the climate becomes more severe - which reflects the common Base Case house configuration used to estimate savings. Second, the two curves cross over in the middle with the greatest percentage savings occurring for the HRV case in the milder climate zones and the No HRV case in colder locations. This may appear surprising but it can be explained by remembering that the benefits of an HRV are both climate-dependent and affected by the house's airtightness. For each month, HOT2000 calculates the natural infiltration rate, compares it to the target total air change rate, and then provides additional mechanical air change to supply the difference. Since the same airtightness is assumed for all six zones, the natural air change rate will provide an increasing amount of the total air change rate in colder climates since the stack effect (the prime driver of natural infiltration in houses) is a function of the indoor-to-outdoor temperature differential. For example, with an airtightness of 2.5 ac/hr₅₀, natural infiltration provides 70% of the winter total air change rate in Zone 4. In Zone 8, this value grows to 83%. Since an HRV only provides heat recovery for the mechanical portion of the total air change rate, the larger natural infiltration rates in colder zones reduces the HRV's benefits. As the house becomes more airtight, the benefits of an HRV grow. Also, remember that the thermal insulation requirements are reduced for most building envelope components for the No HRV case.

The final observation concerning Fig. 1 is that a slight bend is present in the middle of both curves at Zone 7a. This may appear anomalous until it is remembered that the airtightness in this zone was 2.3 ac/hr₅₀ - lower than the assumed value of 2.5 ac/hr₅₀ used to model houses which comply with the prescriptive airtightness measures proposed for Section 9.36. Therefore, no benefits due to improved airtightness were assumed for Zone 7 a) whereas all other zones experienced some energy benefit.

Fig. 1
Annual Energy Savings (%)



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Canada Mortgage and Housing Corporation. April, 2011. "Dwelling Starts, Completions, Under Construction and Newly Completed and Unabsorbed Dwellings – 2010".

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Kidd, Peter. Manitoba Hydro. 2011. Personal communication.

Proskiw, G. September, 2011. "Final Validation of the Proposed Part 9 Prescriptive Requirements For Insulation, Airtightness and Windows, Relative to the Proposed Target of ERS 80. Report prepared for the National Research Council of Canada.

Appendix A

Representativeness Of House #4

House #4 was one of 11 archetype houses used in the development of the proposed requirements for Section 9.36. Although no single house can be judged as truly representative of a sample of houses, nor a population of houses, House #4's behaviour followed the overall trend demonstrated by the 11 archetypes in a more consistent fashion than any of the other houses. For example, the overall energy consumption of the 11 archetypes in the six climate zones, when upgraded to the proposed requirements (using the non-HRV pathway), was 34,167 kWh_e/yr. The average, equivalent consumption for House #4 was 31,417 kWh_e/yr. This was within 6% to 9% of the average values for the 11 archetypes, depending on location.

A comparison was also made between the savings generated by House #4 and two of the other archetypes (#1 and #7) in two locations (Toronto and Winnipeg). These results are summarized in Table A-1.

Table A-1
Representativeness Of House #4 - Typical Percentage Energy Savings

House	Zone 5 (Toronto)		Zone 7a (Winnipeg)	
	No HRV	HRV	No HRV	HRV
#4	8.1%	9.0%	12.7%	12.4%
#1	6.7%	8.5%	11.8%	13.9%
#7	6.0%	6.3%	12.3%	14.0%

COST SUMMARY - HOUSES WITH HRV

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Item	Multiplier (Area/Length/No.)	Units	Zone 4 (<3000 HDD)			Zone 5 (3000 to 3999 HDD)			Zone 6 (4000 to 4999 HDD)			Zone 7a (5000 to 5999HDD)			Zone 7b (6000 to 6999HDD)			Zone 8 (>7000 HDD)		
			Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)
Building Envelope																				
Above-Ground Assemblies																				
Ceilings Below Attics	78.83	m2	\$0.00	\$0		\$2.14	\$0		\$2.14	\$168	90	\$2.31	\$182	125	\$4.79	\$377	265	\$5.90	\$465	416
Cathedral Ceilings & Flat Roofs	0	m2	\$0.30	\$0		\$0.27	\$0		\$0.27	\$0		\$0.30	\$0		\$0.31	\$0		\$0.38	\$0	
Walls	133.53	m2	\$0.00	\$0		\$2.51	\$335	353	\$2.51	\$335	363	\$2.71	\$362	497	\$3.79	\$507	804	\$4.67	\$624	1295
Floors Over Unheated Spaces	0	m2	\$0.30	\$0		\$0.27	\$0		\$0.27	\$0		\$0.30	\$0		\$0.31	\$0		\$0.38	\$0	
Rim Joists	18.2	m2	\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0	
Sub-Total Above-Ground Assemblies				\$0	0		\$335	353		\$503.49	663		\$544	622		\$884	1069		\$1,089	1711
Below-Ground Assemblies																				
Foundation Walls	87.77	m2	\$3.41	\$299	119	\$2.90	\$255	773	\$2.90	\$255	836	\$3.13	\$275	1093	\$3.25	\$285	1154	\$4.00	\$351	2263
Unheated Floors																				
- Below frost line	76.49	m2	\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0	
- Above frost line & crawl spaces	0	m2	\$22.41	\$0		\$20.37	\$0		\$20.37	\$0		\$20.38	\$0		\$21.13	\$0		\$26.04	\$0	
- On permafrost	76.49	m2	\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$0.00	\$0		\$69.00	\$5,278	1216
Slab-On-Grade	0	m2	\$22.41	\$0		\$20.37	\$0		\$20.37	\$0		\$22.00	\$0		\$22.81	\$0		\$28.11	\$0	
Sub-Total Below-Ground Assemblies				\$299	119		\$255	773		\$255	836		\$275	1093		\$285	1154		\$5,629	3479
Windows, Doors and Skylights																				
Windows	30.95	m2	\$0.00	\$0		\$0.00	\$0		\$83.74	\$2,592	1203	\$90.44	\$2,799	1651	\$129.72	\$4,015	2187	\$159.84	\$4,947	3874
Sub-Total Windows, Doors and Skylights				\$0	0		\$0	0		\$2,592	1203		\$2,799	1651		\$4,015	2187		\$4,947	3874
Airtightness																				
Airtightness				\$535	266		\$267	184		\$216	242		\$0	0		\$369	1321		\$772	6499
Sub-Total Airtightness				\$535	266		\$267	184		\$216	242		\$0	0		\$369	1321		\$772	6499
Building Envelope Sub-Total				\$834	385		\$856	1310		\$3,565	2944		\$3,618	3366		\$5,553	5731		\$12,437	15563
Mechanical Systems																				
Heating systems																				
- Upgrade to 92% gas furnace	1	number	\$286.00	\$286	120	\$260.00	\$260	200	\$260.00	\$0		\$280.80	\$281	319	\$291.20	\$291	401	\$358.80	\$0	
- Upgrade to 85% oil furnace furnace	1	number	\$1,144.00	\$0		\$1,040.00	\$0		\$1,040.00	\$0		\$1,123.20	\$0		\$1,164.80	\$0		\$1,435.20	\$1,435	2521
- VB on exterior ducts (9.36.3.2.(5))	0	number	\$12.65	\$0		\$11.50	\$0		\$11.50	\$0		\$12.42	\$0		\$12.88	\$0		\$15.87	\$0	
- Insulate exterior ducts (9.36.3.2.(3))	0	number	\$5.50	\$0		\$5.00	\$0		\$5.00	\$0		\$5.40	\$0		\$5.60	\$0		\$6.90	\$0	
- Install room dampers/controls (9.36.3.6.(4))	0	number	\$88.00	\$0		\$80.00	\$0		\$80.00	\$0		\$86.40	\$0		\$89.60	\$0		\$110.40	\$0	
Sub-Total Heating Systems				\$286	120		\$260	200		\$0	0		\$281	319		\$291	401		\$1,435	2521
DHW systems																				
- Upgrade to 62% gas DHW tank	1	number	\$482.90	\$483	558	\$439.00	\$439	564							\$491.68	\$492	632			
- Upgrade to 90% electric DHW tank or 85% oil DHS tank	1	number							\$175.00	\$175.00	277	\$189.00	\$189.00	245				\$241.50	\$242	173
- Add DHW tank insulation (9.36.4.2.(2))	0	number	\$49.50	\$0		\$45.00	\$0		\$45.00	\$0		\$48.60	\$0		\$50.40	\$0		\$62.10	\$0	
- Install heat traps (9.36.4.3.(1))	1	number	\$38.50	\$39	66	\$35.00	\$35	71	\$35.00	\$35	58	\$37.80	\$38	60	\$39.20	\$39	51	\$48.30	\$48	17
- Insulate 4 m of DHW piping (9.36.4.3.(2))	1	number	\$55.00	\$55	1	\$50.00	\$50	1	\$50.00	\$50	1	\$54.00	\$54	1	\$56.00	\$56	1	\$69.00	\$69	1
- Insulate exterior DHW piping (9.36.4.3.(3))	0	number	\$14.85	\$0		\$13.50	\$0		\$13.50	\$0		\$14.58	\$0		\$15.12	\$0		\$18.63	\$0	
- Insulate DHW recirc piping (9.36.4.3.(4))	0	number	\$16.50	\$0		\$15.00	\$0		\$15.00	\$0		\$16.20	\$0		\$16.80	\$0		\$20.70	\$0	
Sub-Total DHW Systems				\$576	625		\$524	636		\$260	336		\$267	306		\$587	684		\$292	191

COST SUMMARY - HOUSES WITH HRV

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Item	Multiplier (Area/Length/No.)	Units	Zone 4 (<3000 HDD)			Zone 5 (3000 to 3999 HDD)			Zone 6 (4000 to 4999 HDD)			Zone 7a (5000 to 5999HDD)			Zone 7b (6000 to 6999HDD)			Zone 8 (>7000 HDD)		
			Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)
Ventilation systems																				
- Exhaust outlet dampers (9.36.3.3.(1))	0	number	\$22.00	\$0		\$20.00	\$0		\$20.00	\$0		\$21.60	\$0		\$22.40	\$0		\$27.60	\$0	
- Supply inlet dampers (9.36.3.3.(2))	0	number	\$22.00	\$0		\$20.00	\$0		\$20.00	\$0		\$21.60	\$0		\$22.40	\$0		\$27.60	\$0	
- Insulate exterior pipes (9.36.3.4.(2)(b))	0	number	\$16.50	\$0		\$15.00	\$0		\$15.00	\$0		\$16.20	\$0		\$16.80	\$0		\$20.70	\$0	
- Install HRV (9.36.3.9.(1)(2))	1	number	\$1,760.00	\$1,760	339	\$1,600.00	\$1,600	575	\$1,600.00	\$1,600	507	\$1,728.00	\$1,728	552	\$1,792.00	\$1,792	520	\$2,208.00	\$2,208	8
Sub-Total Ventilation Systems				\$1,760	339		\$1,600	575		\$1,600	507		\$1,728	552		\$1,792	520		\$2,208	8
Other Mechanical																				
- Install pool cover (9.36.3.8.(2))	0	number	\$495.00	\$0		\$450.00	\$0		\$450.00	\$0		\$450.00	\$0		\$504.00	\$0		\$504.00	\$0	
- Install swimming pool controls (9.36.4.5.(2))	0	number	\$220.00	\$0	0	\$200.00	\$0	0	\$200.00	\$0	0	\$200.00	\$0	0	\$224.00	\$0	0	\$224.00	\$0	0
Sub-Total Other Mechanical				\$0	0		\$0	0		\$0	0		\$0	0		\$0	0		\$0	0
Mechanical Systems Sub-Total				\$2,622	1,084		\$2,384	1,411		\$1,860	843		\$2,276	1,177		\$2,670	1,605		\$3,936	2,720
SUMMARY AND TOTALS																				
Building Envelope Sub-Total				\$834	385		\$856	1310		\$3,565	2944		\$3,618	3366		\$5,553	5731		\$12,437	15563
Mechanical Systems Sub-Total				\$2,622	1084		\$2,384	1411		\$1,860	843		\$2,276	1177		\$2,670	1605		\$3,936	2720
TOTAL				\$3,457	1469		\$3,240	2721		\$5,425	3787		\$5,893	4543		\$8,223	7336		\$16,373	18283
Energy Consumption, Pre-Section 9.36 (kWhe/yr)					24630		30232		29588		36512		43388		66646					
Savings (kWhe/yr)					1469		2721		3787		4543		7336		18283					
Savings (%)					6.0%		9.0%		12.8%		12.4%		16.9%		27.4%					

Check based on HOT2000 runs using all changes----->

1513

2706

3566

4456

7207

20798

COST SUMMARY - HOUSES WITHOUT HRV

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Item	Multiplier (Area/Length/No.)	Units	Zone 4 (<3000 HDD)			Zone 5 (3000 to 3999 HDD)			Zone 6 (4000 to 4999 HDD)			Zone 7a (5000 to 5999HDD)			Zone 7b (6000 to 6999HDD)			Zone 8 (>7000 HDD)		
			Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)
Building Envelope																				
Above-Ground Assemblies																				
Ceilings Below Attics	78.83	m2	\$ -	\$0		\$ 2.14	\$168	88	\$ 2.14	\$168	90	\$ 4.62	\$364	234	\$ 4.79	\$377	265	\$ 5.90	\$465	417
Cathedral Ceilings & Flat Roofs	0	m2	\$ 0.30	\$0		\$ 0.27	\$0		\$ 0.27	\$0		\$ 0.30	\$0		\$ 0.31	\$0		\$ 0.38	\$0	
Walls	133.53	m2	\$ -	\$0		\$ 3.39	\$452	559	\$ 3.39	\$452	573	\$ 3.66	\$489	787	\$ 15.69	\$2,095	2454	\$ 19.33	\$2,582	3934
Floors Over Unheated Spaces	0	m2	\$ 0.30	\$0		\$ 0.27	\$0		\$ 0.27	\$0		\$ 0.30	\$0		\$ 0.31	\$0		\$ 0.38	\$0	
Rim Joists	18.2	m2	\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0	
Sub-Total Above-Ground Assemblies				\$0	0		\$621	647		\$621	663		\$852	1021		\$2,473	2719		\$3,047	4351
Below-Ground Assemblies																				
Foundation Walls	87.77	m2	\$ 3.41	\$299	119	\$ 2.90	\$255	773	\$ 2.90	\$255	836	\$ 4.71	\$413	1342	\$ 4.89	\$429	1413	\$ 6.02	\$528	3323
Unheated Floors																				
- Below frost line	76.49	m2	\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0	
- Above frost line & crawl spaces	0	m2	\$ 22.41	\$0		\$ 20.37	\$0		\$ 20.37	\$0		\$ 20.38	\$0		\$ 21.13	\$0		\$ 26.04	\$0	
- On permafrost	76.49	m2	\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ -	\$0		\$ 69.00	\$5,278	1216
Slab-On-Grade	0	m2	\$ 22.41	\$0		\$ 20.37	\$0		\$ 20.37	\$0		\$ 22.00	\$0		\$ 22.81	\$0		\$ 28.11	\$0	
Sub-Total Below-Ground Assemblies				\$299	119		\$255	773		\$255	836		\$413	1342		\$429	1413		\$5,806	4539
Windows, Doors and Skylights																				
Windows	30.95	m2	\$ -	\$0		\$ -	\$0		\$ 83.74	\$2,592	1203	\$ 90.44	\$2,799	1651	\$ 129.72	\$4,015	2187	\$ 159.84	\$4,947	3874
Sub-Total Windows, Doors and Skylights				\$0	0		\$0	0		\$2,592	1203		\$2,799	1651		\$4,015	2187		\$4,947	3874
Airtightness																				
Airtightness				\$535	266		\$267	184		\$216	242		\$0	0		\$369	1321		\$772	6469
Sub-Total Airtightness				\$535	266		\$267	184		\$216	242		\$0	0		\$369	1321		\$772	6469
Building Envelope Sub-Total				\$834	385		\$1,142	1604		\$3,683	2944		\$4,065	4014		\$7,286	7640		\$14,572	19233
Mechanical Systems																				
Heating Systems																				
- Upgrade to 92% gas furnace	1	number	\$ 286.00	\$286	120	\$ 260.00	\$260	200	\$ 260.00	\$0		\$ 280.80	\$281	319	\$ 291.20	\$291	401	\$ 358.80	\$0	
- Upgrade to 85% oil furnace furnace	1	number	\$ 1,144.00	\$0		\$ 1,040.00	\$0		\$ 1,040.00	\$0		\$ 1,123.20	\$0		\$ 1,164.80	\$0		\$ 1,435.20	\$1,435	2522
- VB on exterior ducts (9.36.3.2.(5))	0	number	\$ 12.65	\$0		\$ 11.50	\$0		\$ 11.50	\$0		\$ 12.42	\$0		\$ 12.88	\$0		\$ 15.87	\$0	
- Insulate exterior ducts (9.36.3.2.(3))	0	number	\$ 5.50	\$0		\$ 5.00	\$0		\$ 5.00	\$0		\$ 5.40	\$0		\$ 5.60	\$0		\$ 6.90	\$0	
- Install room dampers/controls (9.36.3.6.(4))	0	number	\$ 88.00	\$0		\$ 80.00	\$0		\$ 80.00	\$0		\$ 86.40	\$0		\$ 89.60	\$0		\$ 110.40	\$0	
Sub-Total Heating Systems				\$286	120		\$260	200		\$0	0		\$281	319		\$291	401		\$1,435	2522
DHW Systems																				
- Upgrade to 62% gas DHW tank	1	number	\$ 482.90	\$483	558	\$ 439.00	\$439	564							\$ 491.68	\$492	632			
- Upgrade to 90% electric DHW tank or 85% oil DHS tank	1	number							\$ 175.00	\$175	277	\$ 175.00	\$175	245				\$ 175.00	\$175	173
- Add DHW tank insulation (9.36.4.2.(2))	0	number	\$ 49.50	\$0		\$ 45.00	\$0		\$ 45.00	\$0		\$ 48.60	\$0		\$ 50.40	\$0		\$ 62.10	\$0	
- Install heat traps (9.36.4.3.(1))	1	number	\$ 38.50	\$39	66	\$ 35.00	\$35	71	\$ 35.00	\$35	58	\$ 37.80	\$38	60	\$ 39.20	\$39	51	\$ 48.30	\$48	17
- Insulate 4 m of DHW piping (9.36.4.3.(2))	1	number	\$ 55.00	\$55	1	\$ 50.00	\$50	1	\$ 50.00	\$50	1	\$ 54.00	\$54	1	\$ 56.00	\$56	1	\$ 69.00	\$69	1
- Insulate exterior DHW piping (9.36.4.3.(3))	0	number	\$ 14.85	\$0		\$ 13.50	\$0		\$ 13.50	\$0		\$ 14.58	\$0		\$ 15.12	\$0		\$ 18.63	\$0	
- Insulate DHW recirc piping (9.36.4.3.(4))	0	number	\$ 16.50	\$0		\$ 15.00	\$0		\$ 15.00	\$0		\$ 16.20	\$0		\$ 16.80	\$0		\$ 20.70	\$0	
Sub-Total DHW Systems				\$576	625		\$524	636		\$260	336		\$267	306		\$587	684		\$292	191

COST SUMMARY - HOUSES WITHOUT HRV

\\frc-data\ce\CODES\C C B F C Committees\SC on HSB\02_Tasks\JTGEHSB\Cost&Benefit\JTG_Overall_Cost&Benefit\Reports\[Cost and Benefit Analysis - Summary Tables_Dec5.xlsx]No HRV

Item	Multiplier (Area/Length/No.)	Units	Zone 4 (<3000 HDD)			Zone 5 (3000 to 3999 HDD)			Zone 6 (4000 to 4999 HDD)			Zone 7a (5000 to 5999HDD)			Zone 7b (6000 to 6999HDD)			Zone 8 (>7000 HDD)		
			Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)	Unit Cost	Cost (\$)	Benefit (kWhe)
Ventilation systems																				
- Exhaust outlet dampers (9.36.3.3.(1))	0	number	\$ 22.00	\$0		\$ 20.00	\$0		\$ 20.00	\$0		\$ 21.60	\$0		\$ 22.40	\$0		\$ 27.60	\$0	
- Supply inlet dampers (9.36.3.3.(2))	0	number	\$ 22.00	\$0		\$ 20.00	\$0		\$ 20.00	\$0		\$ 21.60	\$0		\$ 22.40	\$0		\$ 27.60	\$0	
- Insulate exterior pipes (9.36.3.4.(2)(b))	0	number	\$ 16.50	\$0		\$ 15.00	\$0		\$ 15.00	\$0		\$ 16.20	\$0		\$ 16.80	\$0		\$ 20.70	\$0	
- Install HRV (9.36.3.9.(1)(2))	0	number	\$ 1,760.00	\$0		\$ 1,600.00	\$0		\$ 1,600.00	\$0		\$ 1,728.00	\$0		\$ 1,792.00	\$0		\$ 2,208.00	\$0	
Sub-Total Ventilation Systems				\$0	0		\$0	0		\$0	0		\$0	0		\$0	0		\$0	0
Other Mechanical																				
- Install pool cover (9.36.3.8.(2))	0	number	\$ 495.00	\$0		\$ 450.00	\$0		\$ 450.00	\$0		\$ 450.00	\$0		\$ 504.00	\$0		\$ 504.00	\$0	
- Install swimming pool controls (9.36.4.5.(2))	0	number	\$ 220.00	\$0		\$ 200.00	\$0		\$ 200.00	\$0		\$ 200.00	\$0		\$ 224.00	\$0		\$ 224.00	\$0	
Sub-Total Other Mechanical				\$0	0		\$0	0		\$0	0		\$0	0		\$0	0		\$0	0
Mechanical Systems Sub-Total				\$862	745		\$784	836		\$260	336		\$548	625		\$878	1085		\$1,728	2713
SUMMARY AND TOTALS																				
Building Envelope Sub-Total				\$834	385		\$1,142	1604		\$3,683	2944		\$4,065	4014		\$7,286	7640		\$14,572	19233
Mechanical Systems Sub-Total				\$862	745		\$784	836		\$260	336		\$548	625		\$878	1085		\$1,728	2713
TOTAL				\$1,697	1130		\$1,926	2440		\$3,943	3280		\$4,613	4639		\$8,164	8725		\$16,299	21946
Energy Consumption, Pre-Section 9.36 (kWhe/yr)					24630			30232			29588			36512			43388			66646
Savings (kWhe/yr)					1130			2440			3280			4639			8725			21946
Savings (%)					4.6%			8.1%			11.1%			12.7%			20.1%			32.9%

Check based on HOT2000 runs using all changes----->

1151

2418

3266

4550

8567

23011