RESEARCH REPORT

Economic Assessment of Basement System Insulation Options

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FINAL REPORT

ECONOMIC ASSESSMENT OF BASEMENT SYSTEM INSULATION OPTIONS

prepared for
Canada Mortgage and Housing Corporation

by
Ted Kesik
Knowledge Mapping Inc.

C.R. File No. 5610-38

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A report prepared for Canada Mortgage and Housing Corporation by Dr. Ted Kesik, P.Eng. of Knowledge Mapping Inc. The views expressed are those of the author and do not necessarily represent the official views of the Corporation.

Economic Assessment of Residential Basement System Insulation Options

INTRODUCTION

This study updates the 1999 research, the *Economic Assessment of Basement Systems*, and is part of Performance Guidelines for Basement Envelope Systems and Materials, a joint project of Canada Mortgage and Housing Corporation (CMHC) and the National Research Council's (NRC) Institute for Research in Construction (IRC).

Since the 1999 study, fossil fuel energy prices in Canada have risen sharply and their escalation rate has consistently outpaced interest rates. As an example, the Bank of Canada rate over the seven years since the original study has averaged 3.76 per cent. The average annual increase in natural gas prices in the same seven years was approximately 11 per cent.

The 1999 study assumed an interest rate of four per cent and an annual energy escalation rate of one per cent for life-cycle cost assessments. This tended to undervalue the benefits of energy conservation in basements; positioned full-height basement insulation as being only marginally more cost-effective than partial height insulation; and, favoured lower levels of thermal insulation. As well, since 1999 the cost of residential basement construction also rose by about three per cent.

For these reasons, CMHC commissioned this study to update the economic assessment of residential basement insulation options to more accurately reflect the rising costs of basement construction and space-heating energy.

It is important to recognize that, as in the original study, a dollar value could not be put on a number of costs and benefits for various options. For example, in flood-prone areas, external insulation options may minimize the time and costs associated with damages and cleanup following basement flooding. Factors such as thermal comfort and potential for mold growth could not be economically assessed within this study, however, it should be recognized that such factors may significantly influence the value and marketability of housing.

OBJECTIVES

The study's primary objectives were:

1. To update material and labour construction costs for various types of basement systems available in the Canadian housing market;
2. To update energy prices and energy-price escalation rates to take into account expected trends in energy prices;
3. To include a larger basement model to accompany the smaller basement model used in the original study so that the effect of basement size could be compared;
4. To conduct a life-cycle economic assessment taking into account updated construction costs, energy prices and energy-price escalation rates; and
5. To prepare a report on the findings.

METHODOLOGY

This study employed a similar methodology to that used for the 1999 *Economic Assessment of Basement Systems* study. The main difference is that the 1999 builder survey was not repeated. Instead, the 1999 prices were adjusted by using 2006 material costs for thermal and moisture protection measures and applying a construction price index to the 1999 builder unit costs. Recognizing this difference, the steps taken in this study were as follows:

1. Research was undertaken into the construction price index from 1999 to 2005 using Statistics Canada data, which was subsequently compared with R.S. Means Residential Cost Data (1999 versus 2005) to validate the former.

The construction-cost inflation rate for Toronto, Ottawa, Halifax, Edmonton and Victoria was later applied to the 1999 builder unit costs to arrive at 2006 costs. (Note: The costs up to December 2005 were applied in February 2006 assuming a negligible increase for this relatively short time difference).

2. Material costs were surveyed in February 2006 to derive unit costs for the various thermal and moisture protection measures considered in the study. These 2006 costs were later combined with the inflation-adjusted 1999 builder costs to arrive at a total cost for each basement insulation option.
3. A survey of energy prices in February 2006 determined consumer costs by fuel price across the five cities considered in this study. Energy price trends and forecasts were subsequently reviewed to develop reasonable scenarios for price escalation.
4. A larger basement type was developed and modelled in BaseCalc™ so that annual space-heating energy demand for each insulation option was calculated across the five cities this study considered.
5. A new life-cycle cost assessment spreadsheet was assembled for analysis of three different scenarios of energy price escalation. The relationship of the discount or interest rate to the escalation rate for energy is critical when employing the modified, present-worth formula.
6. Following the life-cycle assessment, this report was developed to present the results and interpret their significance.

Because of regional variations in basement construction practices, it has not been possible to address every type of basement system in this study. However, the methodologies that have been developed may be applied by interested parties to yield specialized or localized answers to questions that commonly interest builders, consumers and society.

SOURCES OF INFORMATION

To analyze the various basement insulation options, this study considers the following data was collected and interpreted:

- Capital costs of basement systems and improvements
- Builder carrying costs and profit margins
- Energy prices and forecasts

A large number of computer simulations were also performed using BaseCalc™ to determine the energy performance of three basement classes:

- Class A-3 basements—full-height insulation with proper moisture protection
- Class B basements—partial-height insulation
- Class C basements—uninsulated cellars

The basements were in:

- Victoria
- Edmonton
- Toronto
- Ottawa-Gatineau
- Halifax

ENERGY PRICES AND CONSTRUCTION PRICE INDEXES

Energy and construction prices have risen sharply since 1999. Table 1 summarizes the data used in the current update study. It should be noted, by comparing with the 1999 energy prices listed in Table 2, the cost of fossil fuels has increased more dramatically than construction costs during this period.

Table 1 Energy prices, location factors and construction inflation for selected study locations

	Energy price ($/GJ) February 2006				Location factor	1999–2005 construction inflation
	Gas	**Oil**	**Propane**	**Electricity**		
Toronto	15.01	21.57	29.25	26.67	1.14	135.2%
Ottawa-Gatineau	15.01	22.09	28.85	26.67	1.11	156.5%
Halifax	N/A	23.14	40.71	29.44	0.98	129.7%
Edmonton	7.21	20.29	20.95	27.50	1.01	148.6%
Victoria	15.40	23.53	28.46	19.36	1.07	117.0%
					Average	**137.4%**

Table 2 Energy prices used in original 1999 study

	Energy price ($/GJ) 1999			
	Gas	Oil	Propane	Electricity
Toronto	6.98	9.76	16.42	25.64
Ottawa-Gatineau	6.98	9.76	16.42	20.44
Halifax	N/A	9.47	18.34	26.11
Edmonton	4.64	7.97	13.09	20.86
Victoria	6.98	10.56	16.83	17.00

The life-cycle cost parameters employed in the analyses attempted to portray three energy-price escalation scenarios, as shown in Table 3. A low, future-energy price escalation scenario reflected an historical datum when energy price increases were modest for several decades. The current scenario assumes that energy prices will continue to rise as they have over the past decade. The high scenario reflected the situation where current energy prices in Canada begin to approach prices in other developed countries.

Table 3 Life-cycle cost parameters used in 2006 study

	Future scenarios		
Parameter	**Low**	**Current**	**High**
Interest or discount rate	2%	3%	5%
Energy-escalation rate	4%	7%	12%
Study period (years)	30	30	30

These cost data, along with the BaseCalc™ space-heating energy simulation results, were subsequently applied within the life-cycle cost analyses of the three basement classes.

For more information on basement classes, see *Research Highlight—Occupancy-based Classification System for Design and Construction of Residential Basements*, Canada Mortgage and Housing Corporation, Technical Series 06-109, June 2006.

Table 4 Life-cycle cost assessment of large basement in Toronto – 80 per cent efficiency natural gas

Toronto—Natural gas 80 per cent efficiency, large basement										
Class A-3 Basement—Full-height insulation, unfinished										
Basement option	**R-Value**	**Annual GJ**	**Capital Cost**	**Annual energy**	**LCC of energy**			**LCC of Basement System**		
					Low	**Current**	**High**	**Low**	**Current**	**High**
Ext. XPS	12	17.6	$23,874	$330	$13,575	$18,869	$31,342	$37,450	$42,744	$55,216
Ext. Fibre	9.9	18.8	$23,200	$353	$14,501	$20,156	$33,479	$37,701	$43,356	$56,679
Ext. EPS	11.25	17.9	$22,916	$336	$13,807	$19,191	$31,876	$36,723	$42,107	$54,792
Ext. SPF	12	17.6	$25,080	$330	$13,575	$18,869	$31,342	$38,656	$43,950	$56,422
Int. Fibre	12	17.2	$20,928	$323	$13,267	$18,441	$30,630	$34,195	$39,368	$51,558
Int. Cell.	12	17.2	$21,019	$323	$13,267	$18,441	$30,630	$34,285	$39,459	$51,648
Int. Batt	20	14.3	$21,334	$268	$11,030	$15,331	$25,465	$32,364	$36,665	$46,799
Int. XPS	10	18.4	$23,182	$345	$14,193	$19,727	$32,767	$37,374	$42,909	$55,948
Int. EPS	9	18.9	$22,397	$355	$14,578	$20,263	$33,657	$36,975	$42,660	$56,054
Int. SPF	12	17.2	$25,271	$323	$13,267	$18,441	$30,630	$38,537	$43,711	$55,900
ICFs	22	13.0	$29,941	$244	$10,027	$13,938	$23,150	$39,968	$43,878	$53,091
Class B basement—Partial-height insulation										
Int. Fibre	12	23.5	$16,803	$441	$18,126	$25,195	$41,849	$34,929	$41,998	$58,651
Int. Cell.	12	23.5	$16,842	$441	$18,126	$25,195	$41,849	$34,968	$42,037	$58,691
Int. Batt	20	21.7	$16,978	$407	$16,738	$23,265	$38,643	$33,715	$40,243	$55,621
Int. XPS	10	24.3	$17,773	$456	$18,743	$26,053	$43,273	$36,517	$43,826	$61,047
Int. EPS	9	24.7	$17,435	$463	$19,052	$26,482	$43,986	$36,487	$43,917	$61,421
Class C basement—Uninsulated cellar										
Gas 80%	N/A	53.7	$15,575	$1,008	$41,421	$57,573	$95,629	$56,996	$73,148	$111,204

Table 4 summarizes a typical life-cycle cost assessment for a large basement in Toronto with 80 per cent efficiency natural gas heating. The maximum life-cycle costs for each class of basement are denoted by grey shaded values and the minimum values are denoted by white numbers in black cells. In all cases, the Class A-3 basement system is the most cost-effective under all future energy cost scenarios, when compared to a lower class of basement employing the same thermal-moisture protection option. In this study, it was found that the rankings for life-cycle cost-effectiveness are virtually identical for large basements and small basements. Table 5 summarizes the insulation options assessed in this study.

Table 5 Description of basement insulation options assessed in this study

Insulation option	Label	R (RSI)
1—Exterior extruded polystyrene—2 ½ in.	Ext. XPS	12 (2.11)
2—Exterior glass/mineral fibre—3 in.	Ext. Fibre	9.9 (1.74)
3—Exterior expanded polystyrene—3 in.	Ext. EPS	11.25 (1.98)
4—Exterior sprayed polyurethane foam—2 in.	Ext. SPF	12 (2.11)
5—Interior glass/mineral fibre—3 ½ in.	Int. Fibre	12 (2.11)
6—Interior cellulose—3½ in.	Int. Cell.	12 (2.11)
7—Interior glass/mineral fibre—5 ½ in.	Int. Batt	20 (3.52)
8—Interior extruded polystyrene—2 in.	Int. XPS	10 (1.76)
9—Interior expanded polystyrene—2 ½ in.	Int. EPS	9.4 (1.66)
10—Interior sprayed polyurethane foam—2 in.	Int. SPF	12 (2.11)
11—Insulated concrete forms (generic)	ICFs	22 (3.87)

The difference in annual energy costs between the best- and worst-performing Class A-3 basements in Table 4 is $111 (*ICFs vs. Ext. EPS*).

For Class A-3 basements, the most energy-efficient system is ICFs, and the most cost-effective system utilizes internal fibre-batt insulation with a nominal thermal resistance of R-20 (RSI 3.52).

Among the Class A-3 basements, the highest life-cycle cost systems vary depending on the energy-price escalation scenario. When energy-price escalations are low, the ICF option incurs the highest life-cycle basement system cost because the life-cycle energy savings do not offset the higher installed cost. Under the current energy-price escalation scenario, the exterior spray polyurethane foam insulation system incurs the highest life-cycle basement system cost because the R-12 (RSI 2.11) insulation level is suboptimal relative to its installed cost.

In the case of the high energy-price escalation scenario, the exterior fibre insulation system yields the highest life-cycle basement system cost because the R-9.9 (RSI 1.74) insulation level is suboptimal relative to its installed cost. This indicates that paying a premium for a higher performance thermal–moisture protection option may be justified in the long term when energy-price escalations are forecast to increase sharply. Life-cycle cost relationships were found to be similar across the five locations studied.

CHOOSING BASEMENT INSULATION

In view of the life-cycle cost assessments, and the related published work on basement performance problems, Table 6 presents preferable basement insulation options for new and existing homes.

Note that in all cases, full-height basement insulation is recommended over all other configurations, and it is also advisable to allow for some drying of construction moisture before applying interior insulation in new basements.

In the case of existing basements with moisture problems, it is practical to perform digging and drainage repairs from the outside; hence exterior insulation options may be preferable.

The selection of a suitable basement insulation option is largely governed by the intended use of the basement. Within the spectrum of site conditions encountered by builders across Canada, there can be large lot sizes and natural slopes that allow surface drainage away from the house in all directions, local soils can be free-draining and stable, the water table can be well below the footings and the local climate can be relatively dry most of the time.

In such conditions, a very basic basement configuration meeting minimum code requirements can perform adequately using any of the basement insulation options assessed in this study. Nevertheless, it is improbable that all of those favourable conditions exist at every construction site.

As a result, when the builder (and subsequently the homeowner) is dealing with one, some or many challenging conditions, consideration has to be given to additional measures that may be beyond the code

Table 6 Choosing basement insulation options for new and existing homes

Soil-sewer condition	New	Existing
Well-drained soil, no sewer backup problems	Any option*	Any interior option from 5 to 10
Poorly drained soil, poor site drainage	Exterior options 1, 2, 3, 4 and 11 preferred	Non-vapour permeable interior insulation options 8 or 10 recommended
Rising water table, some sewer backup problems	Exterior options 1, 2, 3, 4 and 11 recommended	Exterior options 1, 2, 3, 4 recommended
Flooding and/or chronic sewer backup problems	Exterior options 1 – 4 and 11 only	Exterior options 1, 2, 3, 4 only

* Refer to Table 5 for description of basement insulation options.

In existing basements, water leaks and sewer backup problems should be corrected prior to insulating. Refer to *Practical Measures for the Prevention of Basement Flooding Due to Municipal Sewer Surcharge: Final Report*, by T. Kesik and Kathryn Seymour, Canada Mortgage and Housing Corporation, 2003. (External Research Program Research Report) 95 pages.

For related information, refer to:

Molds in Finished Basements, 1996. Prepared by Scanada Consultants for CMHC.

Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report. NRC-IRC, 2005.

minimum to compensate for those challenging site conditions. In most cases, exceeding minimum code requirements will be necessary to achieve acceptable levels of performance corresponding to modern consumer expectations, especially for fully finished, liveable basements.

CONCLUSIONS

Based on the findings of this update study, the following conclusions were drawn from the findings:

1. The assumption, made in the original study, that measures that were cost-effective in a small basement would be even more cost-effective in a larger basement has been proven correct. The life-cycle, cost-per-unit floor area for large basement systems is lower than for small basements because, for simple basement geometries, the basement envelope area does not increase linearly with floor area.

2. In all locations, irrespective of the thermal-moisture protection option selected, Class A-3 basements (full-height insulation with proper moisture protection) delivered the lowest energy and total life-cycle costs.

   Class B basements (partial-height insulation) and Class C basements (uninsulated cellars) are not cost-effective for consumers of housing under any energy-pricing scenario.

3. For all types and sizes of basements assessed in this study, the lowest life-cycle energy cost was associated with basements constructed using insulating concrete forms (ICFs).

4. For all types and sizes of basements assessed in this study, the lowest total life-cycle cost was associated with basements insulated internally, full-height to a nominal level of R-20 (RSI 3.52).

5. Where thermal bridging at the basement wall and floor header intersection is controlled, the annual energy demand and operating energy costs for externally vs. internally insulated basements are practically the same. Life-cycle costs for externally insulated basements are marginally higher than basements internally insulated to the same nominal thermal resistance. The difference is largely due to the higher installed cost of external insulation.

6. In exterior-insulated basements supporting masonry veneer, thermal bridging effects at the basement wall and floor header intersection are significant, resulting on average in a 20 per cent increase in the annual energy demand and operating energy costs over the corresponding case where thermal bridging is controlled. This study did not examine a complete floor slab and wall-system insulation wrap strategy, but for basements heated with in-floor hydronic systems, the control of thermal bridging may prove to be a critical for life-cycle cost-effectiveness.

7. There is considerable justification for reviewing the cost-effective levels of thermal insulation for basement systems in regulatory codes and standards governing residential energy efficiency in Canada due to the sharp escalation in energy prices recently experienced and forecasts of the continuation of this trend well into the foreseeable future.

CMHC Project Manager: Don Fugler

Consultant: Ted Kesik, Knowledge Mapping Inc.

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Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1-800-668-2642
Fax: 1-800-245-9274

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LE POINT EN RECHERCHE

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Évaluation économique des différentes options d'isolation thermique des sous-sols de bâtiments résidentiels

INTRODUCTION

La présente étude met à jour la recherche de 1999 portant sur l'Évaluation économique des systèmes de sous-sols *(Economic Assessment of Basement Systems)*, qui fait d'ailleurs partie du projet de recherche conjoint *Lignes directrices sur la performance des systèmes et des matériaux d'enveloppe des sous-sols* mené par la Société canadienne d'hypothèques et de logement (SCHL) et l'Institut de recherche en construction (IRC) du Conseil national de recherches (CNR).

Depuis l'étude de 1999, le prix des combustibles fossiles a connu une hausse si spectaculaire au Canada que leur escalade a constamment surpassé celle des taux d'intérêt. À titre d'exemple, le taux de la Banque du Canada au cours de la période de sept ans qui s'est écoulée depuis l'étude originale s'est établi en moyenne à 3,76 %. Par contre, l'augmentation annuelle moyenne du prix du gaz naturel, au cours de la même période, s'est chiffrée à environ 11 %.

L'étude de 1999 présumait un taux d'intérêt de 4 % et une augmentation annuelle de l'énergie de 1 % pour les estimations de coût global. Elle a eu pour effet général de sous-évaluer les avantages de l'économie d'énergie dans les sous-sols, de marginaliser l'efficience d'isoler les sous-sols sur leur pleine hauteur plutôt qu'en partie, et de favoriser la mise en oeuvre d'un degré moindre d'isolation thermique. Depuis 1999, le coût de construction du sous-sol d'un bâtiment résidentiel a également connu une augmentation d'à peu près 3 %.

C'est pourquoi la SCHL a commandé cette étude visant à actualiser l'évaluation économique des différentes options d'isolation thermique des sous-sols de bâtiments résidentiels en vue de mieux refléter le coût croissant de la construction des sous-sols et de l'énergie destinée au chauffage des locaux.

Il est important de reconnaître qu'il a été impossible, tout comme lors de l'étude originale, de chiffrer certains coûts et avantages des différentes options. Ainsi, par exemple, dans les zones sujettes aux inondations, la mise en oeuvre d'isolant à l'extérieur peut réduire le temps et les coûts associés aux dommages et au nettoyage à la suite de l'inondation du sous-sol. Le confort thermique et le risque de croissance de moisissure s'inscrivent parmi les facteurs qui n'ont pas pu faire l'objet d'une évaluation économique dans le cadre de cette étude; par contre, il faut admettre que ces facteurs sont de nature à exercer une influence considérable sur la valeur et la vente des maisons touchées.

OBJECTIFS

L'étude poursuivait les objectifs suivants :

1. Mettre à jour les coûts des matériaux et de la main-d'oeuvre entrant dans la construction des différents types de sous-sols offerts au sein du marché canadien de l'habitation.
2. Mettre à jour les prix de l'énergie et leur escalade pour tenir compte des tendances escomptées en la matière.
3. Ajouter un modèle de grand sous-sol au modèle de petit sous-sol utilisé lors de l'étude originale de façon à pouvoir comparer l'effet de leur taille.
4. Mener une estimation du coût global tenant compte de la mise à jour des coûts de construction, des prix de l'énergie et de leur escalade.
5. Faire état des résultats.

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MÉTHODE

La présente étude a fait appel à une méthode semblable à celle qui a servi pour l'étude de 1999 *Economic Assessment of Basement Systems*, la principale différence étant que l'enquête menée en 1999 auprès des constructeurs n'a pas été répétée. Les prix de 1999 ont plutôt été rajustés en fonction du coût de 2006 des matériaux assurant l'isolation thermique et la protection contre l'humidité et du recours à un indice des coûts de construction appliqué aux coûts unitaires des constructeurs en 1999. Lors de la présente étude, les étapes adoptées, qui tiennent compte de cette différence, s'expriment comme suit :

1. Une étude a tenté de déterminer l'indice des coûts de construction de 1999 à 2005 à l'aide des données de Statistique Canada, qui a par la suite été comparé aux coûts de la construction résidentielle établis par R.S. Means (données de 1999 par rapport à celles de 2005) pour valider le premier.

   Le taux d'inflation des coûts de construction valable pour Toronto, Ottawa, Halifax, Edmonton et Victoria a par la suite été appliqué aux coûts unitaires des constructeurs en vigueur pour 1999 pour obtenir les coûts de 2006. (Note : Les coûts s'appliquant jusqu'en décembre 2005 ont été appliqués en février 2006, en présumant une augmentation négligeable en raison de la courte période).

2. Les coûts des matériaux ont fait l'objet d'une enquête en février 2006 visant à obtenir les coûts unitaires des différentes mesures d'isolation thermique et de protection contre l'humidité envisagées dans le cadre de l'étude. Les coûts de 2006 ont été plus tard combinés aux coûts des constructeurs de 1999 rajustés en fonction du taux d'inflation, de façon à déterminer le coût total de chaque option d'isolation thermique des sous-sols.

3. Une enquête portant sur les prix de l'énergie effectuée en février 2006 a permis de déterminer le coût pour les consommateurs, selon le prix des sources d'énergie dans les cinq villes retenues aux fins de l'étude. Les tendances et les prévisions des prix de l'énergie ont par la suite été revues pour élaborer des scénarios raisonnables d'escalade des prix.

4. Un type de grand sous-sol a été élaboré et modélisé en BaseCalc MC pour calculer la demande annuelle d'énergie de chauffage des locaux nécessaire pour chacune des options d'isolation thermique dans les cinq villes visées par l'étude.

5. Un nouveau chiffrier d'évaluation du coût global a été constitué pour fins d'analyse des trois différents scénarios d'escalade des prix de l'énergie. Le rapport entre le taux d'actualisation ou le taux d'intérêt et l'escalade des prix de l'énergie est essentiel au moment d'employer la formule modifiée d'établissement de la valeur actuelle.

6. Après l'estimation du coût global, le rapport livre les résultats et interprète leur importance.

En raison des différences régionales des méthodes de construction des sous-sols, il n'a pas été possible d'envisager tous les types de sous-sols dans l'étude. Les parties intéressées peuvent toutefois appliquer les méthodes élaborées pour obtenir des solutions spécialisées ou localisées aux questions qui intéressent particulièrement les constructeurs, les consommateurs et la société.

SOURCES D'INFORMATION

Pour analyser les différentes options d'isolation des sous-sols touchées par la présente étude, les données suivantes ont été recueillies et interprétées :

- le coût d'immobilisations des systèmes de sous-sols et des améliorations;
- les frais de possession des constructeurs et leur marge bénéficiaire;
- les prix de l'énergie et les prévisions.

Un grand nombre de simulations informatiques ont été effectuées à l'aide de BaseCalcMC en vue de déterminer la performance énergétique de trois catégories de sous-sols :

- catégorie A-3 : murs isolés sur leur pleine hauteur et dotés d'une protection tout indiquée contre l'humidité;
- catégorie B : murs isolés sur une partie de leur hauteur;
- catégorie C : cave non isolée.

Les sous-sols de maisons étaient situés à :

- Victoria;
- Edmonton;
- Toronto;
- Ottawa-Gatineau;
- Halifax.

INDICES DES PRIX DE L'ÉNERGIE ET DES COÛTS DE CONSTRUCTION

Les prix de l'énergie et les coûts de construction ont accusé une forte hausse depuis 1999. Le tableau 1 résume les données utilisées dans la présente étude de mise à jour. On doit prendre note que, par comparaison avec les prix de l'énergie de 1999 dont fait état le tableau 2, le coût des combustibles fossiles a connu une hausse plus spectaculaire que les coûts de construction pendant la même période.

Tableau 1 Prix de l'énergie, facteurs d'endroit et inflation des coûts de construction de certaines villes retenues pour les besoins de l'étude

	Prix de l'énergie ($/GJ) Février 2006				Facteur d'endroit	Inflation des coûts de construction de 1999 à 2005
	Gaz	Mazout	Propane	Électricité		
Toronto	15,01	21,57	29,25	26,67	1,14	135,2 %
Ottawa-Gatineau	15,01	22,09	28,85	26,67	1,11	156,5 %
Halifax	N.D.	23,14	40,71	29,44	0,98	129,7 %
Edmonton	7,21	20,29	20,95	27,50	1,01	148,6 %
Victoria	15,40	23,53	28,46	19,36	1,07	117,0 %
					Moyenne	**137,4 %**

Tableau 2 Prix de l'énergie employés dans l'étude originale de 1999

	Prix de l'énergie ($/GJ), 1999			
	Gaz	Mazout	Propane	Électricité
Toronto	6,98	9,76	16,42	25,64
Ottawa-Gatineau	6,98	9,76	16,42	20,44
Halifax	N.D.	9,47	18,34	26,11
Edmonton	4,64	7,97	13,09	20,86
Victoria	6,98	10,56	16,83	17,00

Les paramètres du coût global employés lors des analyses visaient à brosser trois scénarios d'escalade du prix de l'énergie, comme le démontre le tableau 3. Le scénario d'une faible augmentation des prix futurs de l'énergie a reflété fidèlement une donnée historique alors que le prix de l'énergie a connu des augmentations modestes pendant plusieurs décennies. Le scénario courant présume que le prix de l'énergie continuera d'augmenter comme ce fut le cas au cours de la dernière décennie. Le scénario d'une augmentation élevée présumait que les prix de l'énergie au Canada commencent à s'approcher de ceux que connaissent les autres pays industrialisés.

Tableau 3 Paramètres du coût global employés lors de l'étude de 2006

	Futurs scénarios		
Paramètre	**Faible**	**Courant**	**Élevé**
Taux d'intérêt ou d'actualisation	2 %	3 %	5 %
Escalade du prix de l'énergie	4 %	7 %	12 %
Période à l'étude (années)	30	30	30

Ces coûts, de même que les résultats de la simulation de l'énergie de chauffage des locaux obtenus grâce au recours à BaseCalc MC, ont été par la suite appliqués au cours des analyses du coût global des trois catégories de sous-sols.

Pour obtenir davantage de précisions au sujet des catégories de sous-sols, veuillez consulter le *Point en recherche — Catégorisation selon l'usage pour la conception et la construction des sous-sols de bâtiments résidentiels*, Société canadienne d'hypothèques et de logement, série technique 06-109, juin 2006.

Tableau 4 Évaluation du coût global d'un grand sous-sol de maison à Toronto, efficacité du gaz naturel à 80 %

Toronto — Efficacité du gaz naturel à 80 %, grand sous-sol										
Sous-sol de catégorie A-3, non aménagé, murs isolés sur leur pleine hauteur										
Option d'isolation	**Valeur R**	**GJ annuels**	**Coût d'immob.**	**Énergie annuelle**	**Coût global de l'énergie**			**Coût global du sous-sol**		
					Faible	**Courant**	**Élevé**	**Faible**	**Courant**	**Élevé**
XPS ext.	12	17,6	23 874 $	330 $	13 575 $	18 869 $	31 342 $	37 450 $	42 744 $	55 216 $
Fibre ext.	9.9	18,8	23 200 $	353 $	14 501 $	20 156 $	33 479 $	37 701 $	43 356 $	56 679 $
EPS ext.	11.25	17,9	22 916 $	336 $	13 807 $	19 191 $	31 876 $	36 723 $	42 107 $	54 792 $
SPF ext.	12	17,6	25 080 $	330 $	13 575 $	18 869 $	31 342 $	38 656 $	43 950 $	56 422 $
Fibre int.	12	17,2	20 928 $	323 $	13 267 $	18 441 $	30 630 $	34 195 $	39 368 $	51 558 $
Cell. Int.	12	17,2	21 019 $	323 $	13 267 $	18 441 $	30 630 $	34 285 $	39, 459 $	51 648 $
Mat. Int.	20	14,3	21 334 $	268 $	11 030 $	15 331 $	25 465 $	32 364 $	36 665 $	46 799 $
XPS int.	10	18,4	23 182 $	345 $	14 193 $	19 727 $	32 767 $	37 374 $	42 909 $	55 948 $
EPS int.	9	18,9	22 397 $	355 $	14 578 $	20 263 $	33 657 $	36 975 $	42 660 $	56 054 $
SPF int.	12	17,2	25 271 $	323 $	13 267 $	18 441 $	30 630 $	38 537 $	43 711 $	55 900 $
CI	22	13,0	29 941 $	244 $	10 027 $	13 938 $	23 150 $	39 968 $	43 878 $	53 091 $
Sous-sol de catégorie B, murs isolés sur une partie de leur hauteur										
Fibre int.	12	23,5	16 803 $	441 $	18 126 $	25 195 $	41 849 $	34 929 $	41 998 $	58 651 $
Cell. Int.	12	23,5	16 842 $	441 $	18 126 $	25 195 $	41 849 $	34 968 $	42 037 $	58 691 $
Mat. Int.	20	21,7	16 978 $	407 $	16 738 $	23 265 $	38 643 $	33 715 $	40 243 $	55 621 $
XPS int.	10	24,3	17 773 $	456 $	18 743 $	26 053 $	43 273 $	36 517 $	43 826 $	61 047 $
EPS int.	9	24,7	17 435 $	463 $	19 052 $	26 482 $	43 986 $	36 487 $	43 917 $	61 421 $
Sous-sol de catégorie C, cave non isolée										
Gaz 80 %	N.D.	53,7	15 575 $	1 008 $	41 421 $	57 573 $	95 629 $	56 996 $	73 148 $	111 204 $

Le tableau 4 résume une estimation type du coût global d'un grand sous-sol d'habitation située à Toronto, le chauffage au gaz naturel enregistrant une efficacité de 80 %. Les coûts globaux maximaux de chaque catégorie de sous-sol sont présentés dans une zone grise ombragée et les valeurs minimales sont représentées par des chiffres en blanc dans des cellules noires. Dans tous les cas, le sous-sol de catégorie A-3 affiche le meilleur rapport coût-efficacité, quel que soit le futur scénario du coût de l'énergie, comparativement à un sous-sol de catégorie inférieure dotée de la même isolation thermique et de la même protection contre l'humidité. Dans cette étude, on a découvert que les cotes du rapport coût-efficacité global sont pratiquement identiques tant pour les grands sous-sols que pour les petits. Le tableau 5 résume les options d'isolation thermique évaluées lors de l'étude.

La différence des frais d'énergie annuels entre les sous-sols de catégorie A-3 les plus performants et les moins performants dont fait état le tableau 4 est de 111 $ (*coffrages isolants comparativement aux panneaux EPS ext.*).

Pour les sous-sols de catégorie A-3, les coffrages isolants représentent le système le plus éconergétique et le système présentant le meilleur rapport coût-efficacité fait appel à des matelas isolants du côté intérieur, assortis d'une résistance thermique nominale de R 20 (RSI 3,52).

Parmi les sous-sols de catégorie A-3, les systèmes présentant le coût global le plus élevé varient selon le scénario d'escalade du prix de l'énergie. Lorsque le prix de l'énergie subit de faibles hausses, l'option des coffrages isolants entraîne le coût global le plus élevé puisque les économies d'énergie ne compensent pas le coût de mise en œuvre supérieur. Aux termes du scénario courant d'escalade du prix de l'énergie, la mousse isolante de polyuréthane projetée du côté extérieur entraîne le coût global le plus élevé puisque l'isolant assorti d'une valeur de résistance thermique R 12 (RSI 2,11) est moins qu'optimal par rapport au coût de mise en œuvre.

Tableau 5 Description des techniques d'isolation des sous-sols évaluées lors de l'étude

Option d'isolation thermique	Étiquette	R (RSI)
1—Polystyrène extrudé extérieur, 2 ½ po	XPS ext.	12 (2,11)
2—Fibre de verre/fibre minérale, extérieur, 3 po	Fibre ext.	9,9 (1,74)
3—Polystyrène expansé extérieur, 3 po	EPS ext.	11,25 (1,98)
4—Mousse de polyuréthane projetée, extérieur, 2 po	SPF ext.	12 (2,11)
5—Fibre de verre/minérale, extérieur, 3 ½ po	Fibre int.	12 (2,11)
6—Cellulose intérieure, 3 ½ po	Cell. int.	12 (2,11)
7—Fibre de verre/minérale, intérieur, 5 ½ po	Mat. int.	20 (3,52)
8—Polystyrène extrudé intérieur, 2 po	XPS int.	10 (1,76)
9—Polystyrène expansé intérieur, 2 ½ po	EPS int.	9,4 (1,66)
10—Mousse de polyuréthane projetée, intérieur, 2 po	SPF int.	12 (2,11)
11—Coffrages isolants	CI	22 (3,87)

Dans le scénario d'une hausse élevée du prix de l'énergie, l'isolant fibreux extérieur donne lieu au coût global le plus élevé puisque sa valeur de résistance thermique de R 9,9 (RSI 1,74) est moins qu'optimale par rapport au coût de mise en œuvre. Voilà qui justifie d'engager un supplément pour obtenir à longue échéance une isolation thermique et une protection contre l'humidité davantage performantes lorsqu'on prévoit une hausse spectaculaire du prix de l'énergie. Les rapports de coût global, a-t-on découvert, sont semblables dans les cinq endroits étudiés.

CHOIX DE L'ISOLANT THERMIQUE DU SOUS-SOL

Compte tenu des estimations de coût global et des travaux diffusés sur les problèmes de performance des sous-sols, le tableau 6 livre les options préférables d'isolation des sous-sols aussi bien pour les maisons neuves que les maisons existantes.

À noter qu'il est recommandé dans tous les cas d'isoler les murs de sous-sol sur leur pleine hauteur et même d'autoriser l'assèchement d'une partie de l'humidité des matériaux de construction avant de mettre en œuvre l'isolant thermique du côté intérieur du sous-sol d'une maison neuve.

Quant aux sous-sols de bâtiments existants aux prises avec des problèmes d'humidité, il vaut mieux creuser et corriger les problèmes de drainage depuis l'extérieur et privilégier l'isolation thermique extérieure.

Le choix d'une option convenable d'isolation thermique du sous-sol de la maison est largement fonction de l'utilisation escomptée. Dans la gamme de conditions d'emplacement auxquelles font face les constructeurs du Canada, il peut y avoir des lots de dimensions importantes et des pentes naturelles qui éloignent les eaux de surface de la maison et ce, dans toutes les directions, le sol de la région peut bien se drainer et présenter une composition stable, la nappe phréatique peut se trouver bien en-deçà des semelles et le climat régional peut s'avérer plutôt sec la plupart du temps.

En pareilles situations, un modèle vraiment fondamental de sous-sol respectant les exigences minimales du code peut afficher une bonne tenue en service s'il fait appel à n'importe quelle option d'isolation thermique évaluée dans l'étude. Néanmoins, il est improbable que chaque emplacement réunisse toutes les conditions favorables.

En conséquence, le constructeur (et par la suite le propriétaire-occupant) qui doit composer avec une, quelques-unes ou de nombreuses situations difficiles doit envisager des mesures supplémentaires qui vont au-delà des exigences minimales du code. Dans la plupart des cas, il faudra dépasser les exigences minimales du code pour obtenir un niveau de performance acceptable, correspondant aux attentes du consommateur d'aujourd'hui, surtout s'il s'agit d'un sous-sol habitable, pleinement aménagé.

CONCLUSIONS

Les résultats de l'étude de mise à jour permettent de dégager les conclusions suivantes :

1. Les hypothèses de l'étude originale voulant que les mesures efficientes prises à l'égard d'un petit sous-sol le soient davantage dans un grand sous-sol se sont révélées justes. Le coût global par surface unitaire d'un grand sous-sol est inférieur à celui d'un sous-sol petit puisque, pour les formes de sous-sol simples, l'enveloppe du sous-sol n'accuse pas d'augmentation linéaire en fonction de l'aire de plancher.

Tableau 6 Choix d'options d'isolation thermique du sous-sol de maisons neuves ou existantes

État du sol et des égouts	Maison neuve	Maison existante
Sol bien drainé, aucun refoulement d'égout	N'importe quelle option*	Toute option intérieure, de 5 à 10
Sol mal drainé, mauvais drainage de l'emplacement	Options extérieures 1, 2, 3, 4 et 11 préférables	Options d'isolant intérieur non perméable à la vapeur d'eau 8 ou 10 recommandées
Élévation de la nappe phréatique, certains refoulements d'égout	Options extérieures 1, 2, 3, 4 et 11 recommandées	Options extérieures 1, 2, 3, 4 recommandées
Inondations et/ou refoulements d'égout chroniques	Options extérieures 1 à 4 et 11 seulement	Options extérierues 1, 2, 3, 4 seulement

*Consultez le tableau 5 pour obtenir la description des options d'isolation thermique des sous-sols.

Dans les sous-sols de maisons existantes, les infiltrations d'eau et les refoulements d'égout doivent être corrigés avant la mise en œuvre d'isolant thermique. Veuillez consulter le rapport de recherche intitulé *Mesures pratiques visant la prévention des inondations de sous-sol résultant de refoulements d'égout*, par T. Kesik et Kathryn Seymour, Société canadienne d'hypothèques et de logement, 2003. (Rapport rédigé dans le cadre du Programme de subventions de recherche), 95 pages.

Pour obtenir des renseignements connexes, veuillez consulter :

La moisissure dans les sous-sols aménagés, 1996. Rédigé par Scanada Consultants à l'intention de la SCHL.

Performance Guidelines for Basement Envelope Systems and Materials : rapport de recherche final, NRC-IRC, 2005.

2. À tous les endroits, quelle que soit l'option d'isolation thermique et de protection contre l'humidité retenue, les sous-sols de catégorie A-3 (isolation thermique sur toute la hauteur et protection tout indiquée contre l'humidité) permettent d'obtenir les frais d'énergie et le coût global les plus bas.

   Les sous-sols de catégorie B (murs isolés sur une partie de leur hauteur) et les sous-sols de catégorie C (caves non isolées) ne s'avèrent pas efficients pour les consommateurs envisageant l'un ou l'autre scénario des prix de revient de l'énergie.

3. Pour tous les types et toutes les tailles de sous-sols évalués lors de l'étude, le coût d'énergie global le plus bas a été associé aux sous-sols réalisés à l'aide de coffrages isolants (CI).

4. Pour tous les types et toutes les tailles de sous-sols évalués lors de l'étude, le coût global le plus faible a été associé aux sous-sols isolés de l'intérieur, sur leur pleine hauteur, assortis d'une valeur de résistance thermique de R 20 (RSI 3,52).

5. Lorsqu'on élimine les ponts thermiques à l'intersection des murs de sous-sol et de la solive de rive du plancher, la demande annuelle d'énergie et les coûts de l'énergie consommée pour les sous-sols isolés de l'extérieur plutôt que de l'intérieur sont pratiquement les mêmes. Les coûts globaux des sous-sols isolés de l'extérieur sont légèrement supérieurs à ceux des sous-sols isolés de l'intérieur assortis de la même résistance thermique nominale. La différence est principalement attribuable au coût plus élevé de la mise en œuvre de l'isolant du côté extérieur.

6. Dans les sous-sols isolés de l'extérieur portant un placage de maçonnerie, les effets des ponts thermiques à l'intersection des murs du sous-sol et de la solive de rive du plancher sont importants, puisqu'ils expliquent, en moyenne, une augmentation de 20 % de la demande annuelle d'énergie et des frais d'utilisation de l'énergie par rapport au cas correspondant où les ponts thermiques sont éliminés. L'étude n'a pas porté sur une stratégie intégrale d'isolation thermique de la dalle de plancher et des murs, mais sur les sous-sols chauffés à l'aide d'un système à eau chaude encastré dans le plancher, l'élimination des ponts thermiques peut s'avérer essentielle pour parvenir à l'efficacité du coût global.

7. Il est vraiment justifié de revoir les niveaux d'efficience de l'isolation thermique des sous-sols dans les codes et les normes régissant l'efficacité énergétique des maisons au Canada en raison de l'escalade fulgurante du prix de l'énergie que nous avons connue dernièrement et des prévisions témoignant de la poursuite de cette tendance dans l'avenir prévisible.

Directeur de projet à la SCHL : Don Fugler

Consultants pour le projet de recherche : Ted Kesik, Knowledge Mapping Inc.

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Ottawa (Ontario)
K1A 0P7
Téléphone : 1-800-668-2642
Télécopieur : 1-800-245-9274

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CMHC SCHL

National Office
700 Montreal Road
Ottawa ON K1A 0P7
Telephone: (613) 748-2000

Bureau national
700 chemin de Montréal
Ottawa ON K1A 0P7
Téléphone : (613) 748-2000

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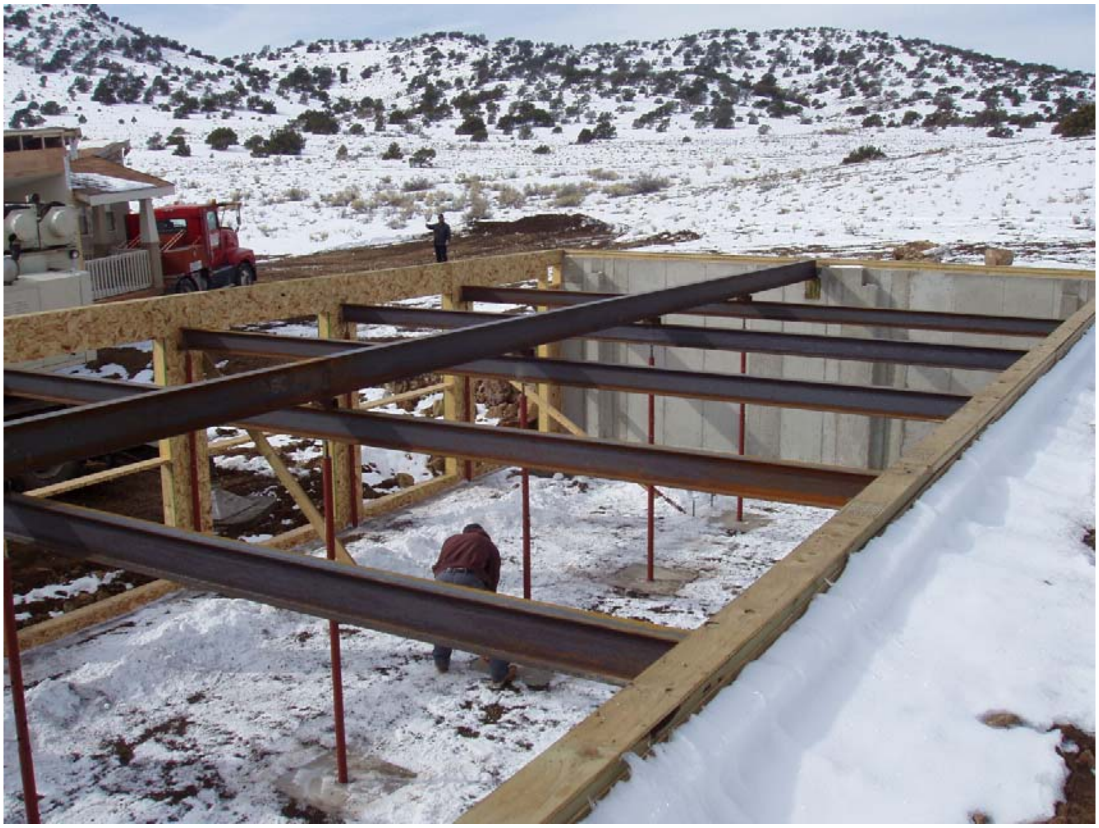

INTRODUCTION

Since the completion of the original 1999 *Economic Assessment of Basement Systems* study, fossil fuel energy prices in Canada have risen sharply and the escalation rate of energy prices has consistently outpaced interest rates. As an example, the Bank of Canada rate over the 7 year period since the original study was conducted has averaged 3.76% while the average annual increase in natural gas prices over the same time period was approximately 11%. During the 1999 study, an interest rate of 4% and an annual energy escalation rate of 1 % were assumed in the life cycle cost assessments. This tended to under value the benefits of energy conservation in basements and positioned full-height basement insulation as being only marginally more cost effective than partial height insulation, as well as favouring lower levels of thermal insulation. During this same period, the cost of residential basement construction also escalated by approximately 37%. For these reasons, CMHC commissioned this study to provide an updated economic assessment of basement system insulation options that more accurately reflects the rising costs of basement construction and space heating energy.

It is important to recognize that similar to the original study, a number of costs and benefits for various basement system options could not be monetized. For example, in flood-prone areas, external basement insulation options may minimize the time and costs associated with damages and cleanup following a basement flooding event. Factors such as thermal comfort and potential for mold growth could not be economically assessed within this study, however, it should be recognized that such factors may significantly influence the value and marketability of housing.

Objectives

The primary objectives of this study were as follows:

1. To update the construction costs (material and labour) for various classes of basement systems currently available in the Canadian residential housing marketplace;
2. To update energy prices and energy price escalation rates to take into account expected trends in the energy marketplace;
3. To include a larger basement model to accompany the smaller basement model used in the original study so that the effect of basement size could be comparatively assessed;
4. To conduct a life cycle economic assessment taking into account the updated construction costs, energy prices and energy price escalation rates; and
5. To prepare a report on the findings related to the preceding objectives.

Methodology

This study employed a similar methodology to that associated with the 1999 *Economic Assessment of Basement Systems* study. The main difference is that the builder survey conducted in 1999 was not repeated due to a lack of resources. Instead, the 1999 prices were adjusted by employing 2006 material costs for thermal and moisture protection measures, and applying a construction price index to the 1999 builder unit costs. Recognizing this difference, the steps taken in this study are as follows:

1. Research was undertaken into the construction price index from 1999 to 2005 using Statistics Canada data, which was subsequently compared with R.S. Means Residential Cost Data (1999 versus 2005) to validate the former. The construction cost inflation rate for each of Toronto, Ottawa, Halifax, Edmonton and Victoria was later applied to the 1999 builder unit costs to arrive at 2006 costs. (Note: The costs up to December 2005 were applied in February 2006 assuming a negligible increase for this relatively short time difference).
2. Material costs were subsequently surveyed in February 2006 to derive unit costs for the various thermal and moisture protection measures considered in the study. These 2006 costs were later combined with the inflation adjusted 1999 builder costs to arrive at a total cost for each basement system insulation option.
3. A survey of energy prices and was conducted in February 2006 to determine consumer costs by fuel price across the 5 locations considered in this study. Energy price trends and forecasts were subsequently reviewed to develop reasonable energy price escalation scenarios.
4. A larger basement type was developed and modeled in BASECALC™ so that annual space heating energy demand for each insulation option was calculated across all 5 locations considered in the study.
5. A new life cycle cost assessment spreadsheet was assembled so that three different energy price escalation scenarios could be analyzed. The relationship of the discount or interest rate to the escalation rate for energy is critical when employing the modified present worth formula.
6. Following the life cycle assessment process, this report was developed to present the results and provide an interpretation of their significance.

Due to the regional variations in basement construction practices across Canada, it has not been possible to address every type of basement system in this study. However, the methodologies which have been developed may be applied by interested parties to yield specialized/localized answers to questions which commonly interest builders, consumers and society.

Description of Basement Models

The approach taken to basement modeling in this study is consistent with the original 1999 study. However, a larger basement type was developed so that the sensitivity of life cycle cost to basement size could be assessed.

The small basement model used for estimating costs and operating energy performance is depicted in Figure 1, while the large basement model appears in Figure 2. Critical features of the basement models are:

1. The average height of the small basement walls above grade is set at 1 foot (300 mm) in keeping with conventional practices for typical small new homes. For the large basement, the height above grade is set at 2 feet (600 mm), as larger basement window heights are common in larger custom houses. These variations enabled a more realistic modelling of the above-grade heat loss.
2. No windows are included in the basement models, recognizing that these are usually provided. The difficulty associated with the inclusion of windows is that the cost of the windows must be factored into the total basement system cost, and their orientation impacts solar gains. Window qualities and costs vary significantly, and the cost implications of window wells must also be considered. The windowless model enables more efficient economic and thermal analyses.

PARAMETER	QUANTITY	UNITS
Length	28	ft
Width	24	ft
Height	8	ft
Perimeter	104	ft
Area	672	ft2
Volume	5376	ft3
Fdn. Wall Area	832	ft2
Above-Grade	104	ft2
Below-Grade	728	ft2

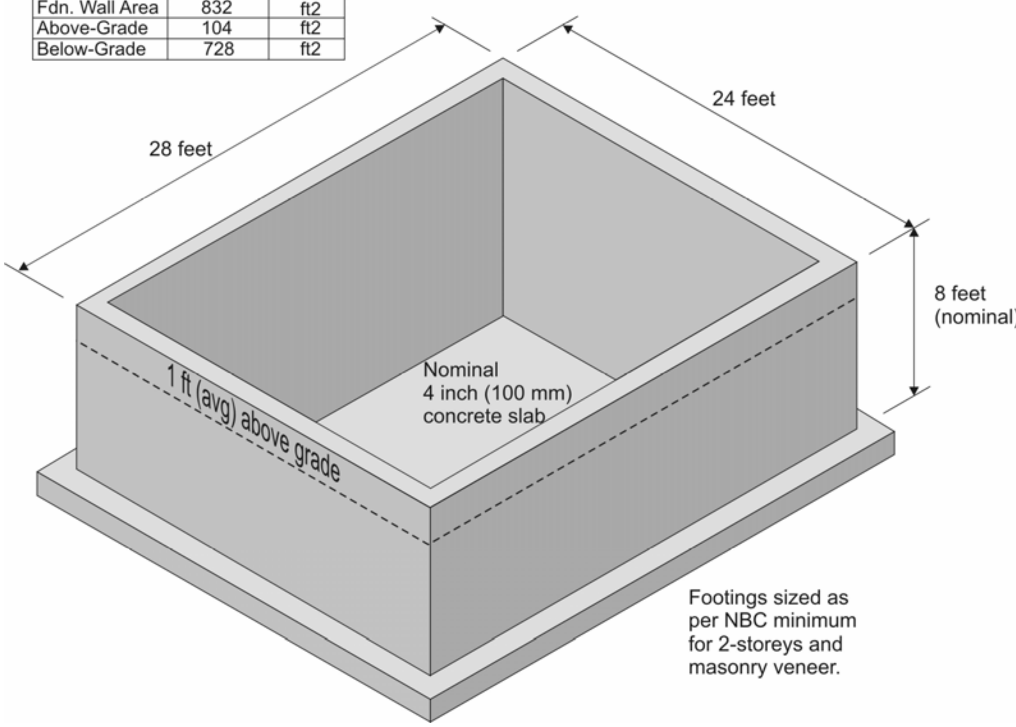

Figure 1. Physical characteristics of small benchmark basement model.

PARAMETER	QUANTITY	UNITS
Length	48	ft
Width	32	ft
Height	8	ft
Perimeter	160	ft
Area	1536	ft2
Volume	12288	ft3
Fdn. Wall Area	1280	ft2
Above-Grade	320	ft2
Below-Grade	960	ft2

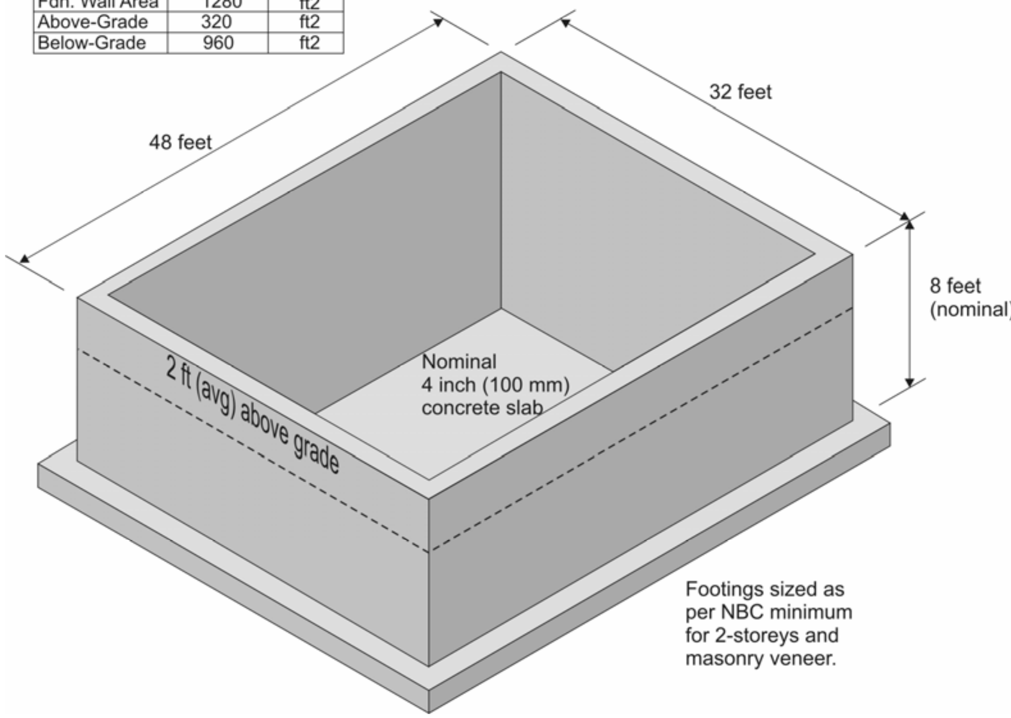

Figure 2. Physical characteristics of large benchmark basement model.

Basement Classification System

This study considers three classes of basements developed during the Basement Guidelines project and described in Table 1. The Basement Guidelines project recognized that while consensus had not been reached on minimum requirements for basements that satisfied the whole range of consumer expectations, there was an opportunity to develop an approach that was consistent with the newly emerging objective-based codes.

During the development of these guidelines it became apparent that in Canada, there exist distinct regional approaches to, and expectations of, basement construction. Ideally, recognition of the diverse use of basements and expectations would be best served by a classification system based on its intended use and the intensity, duration and frequency of environmental loads.

For the purposes of this study, the Class A-3 basement represents a full-height insulated basement that is not finished. The Class B basement is partially insulated and may be convertible to a Class A basement at some future point in time. The Class C basement is not practically convertible into a Class A basement because it lacks adequate moisture protection of the below-grade walls (i.e., no explicit drainage layer installed).

CLASS	INTENDED USE	SERVICE CRITERIA	LIMITATIONS/ALLOWANCES
A-1	Separate dwelling unit.	• Satisfies consumer expectations for control of heat, moisture, air and radiation. • Access/egress, fire & sound separation, and fenestration meet all Code requirements. • Separate environmental control system. • Thermal comfort comparable to above-grade storeys of the dwelling.	• Not suitable for flood prone areas, or areas prone to sewer backup. • Basement can be finished with materials that are moisture or water sensitive. • Virtually defect free construction. • Redundancy of critical control measures provided.
A-2	Liveable space (e.g., family room, home office, etc.)	• Satisfies consumer expectations for control of heat, moisture, air and radiation. • Thermal comfort comparable to above-grade storeys of the dwelling.	• Not suitable for flood prone areas, or areas prone to sewer backup. • Basement can be finished with materials that are moisture or water sensitive. • Virtually defect free construction. • Redundancy of critical control measures provided.
A-3	Near-liveable (e.g. unfinished surfaces)	• Satisfies all functions of the basement envelope, except for comfort, and is unfinished (e.g. no flooring nor carpet, paint,etc.)	• Virtually defect free construction. • Redundancy of critical control measures provided.
B	Convertible or adaptable basement.	• Satisfies minimum requirements for control of heat, moisture, air and radiation (e.g. no explicit wall drainage layer) • Thermal comfort can be upgraded to same quality as above-grade storeys of the dwelling. (e.g. Partially insulated wall)	• Not suitable for flood prone areas, or areas prone to sewer backup. • All structural and interior finishing materials (if any) must recover to original specifications after wetting and drying. • Practically free of defects in free-draining soils where adequate site drainage has been provided. • Normal frequency of defects can be expected otherwise.
C	Basement/cellar - convertible or adaptable at significant future premium.	• Unfinished basement with no intentional control of heat, moisture, air and radiation.	• Practically free of defects in free-draining soils where adequate site drainage has been provided. • Normal frequency of defects can be expected otherwise.
D	Basement serving a dwelling in a flood-prone area, or area prone to sewer backup.	• Class A-1, A-2 or A-3, B or C service criteria may apply.	• Interior finishes capable of withstanding periodic wetting, drying, cleaning and disinfecting.
E	Basement acting as a structural foundation only.	• Acceptable factor of safety for structural performance including frost heaving, adhesion freezing and expansive soils.	• Not intended to be inside the building envelope and no finishing intended. • Floor separating basement and indoors is now the building envelope and must address all functions. • Equipment in basement must be rated to operate outdoors or located in a suitably conditioned enclosure.
Note: Minimum requirements for health and safety are assumed for all of the basement classes listed above. In the case of the Class E basement, only the structural safety requirements are addressed.			

Table 1. Classification of basements by intended use (Basement Guidelines project).

Moisture, Thermal and Air Leakage Protection Options

The combination of materials and assemblies needed to satisfy the requirements for moisture, thermal and air leakage protection in basements is often guided by the placement of insulation with respect to the foundation walls. Figure 3 delineates conventional basement system alternatives according to insulation placement and type of material and lists the options considered in this study.

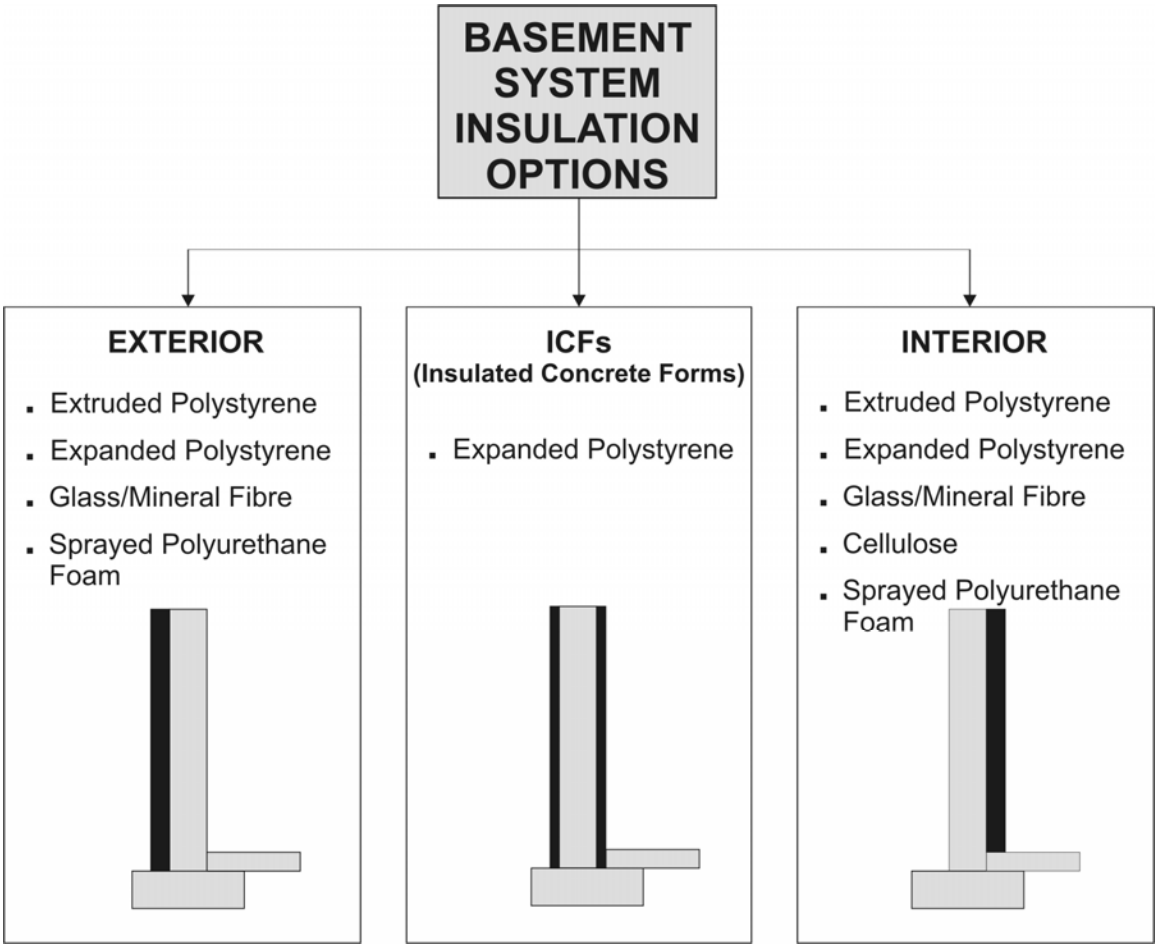

Figure 3. Basement system alternatives considered in the study bases on thermal insulation placement.

These options were applied to actual basement assemblies to arrive at a number of basement system types depicted in Figures 4 to 7, inclusive. It is important to recognize that in each of these instances, only the full-height basement insulation scheme is illustrated. Partial-height insulation schemes, where practical, simply reduce the height of the insulation below grade with no changes to materials or construction. Insulated basement floors are also not shown in these figures, as these are beyond the scope of this study. (Refer to an analysis of insulation options for heated slabs in the *National Energy Code for Houses, 1995*.)

Figure 4 depicts the most common approach to the insulation of new residential basements. The provision of a drainage layer is shown in the instance of full-height basement insulation. It should be recognized that while a foundation drainage layer is not explicitly required in the National Building Code, in some jurisdictions, such as Ontario, it is required for basements insulated to a depth of 3 feet (900 mm) or more below grade. A variety of approved insulation materials are available to fill the cavity between and/or behind the wall strapping.

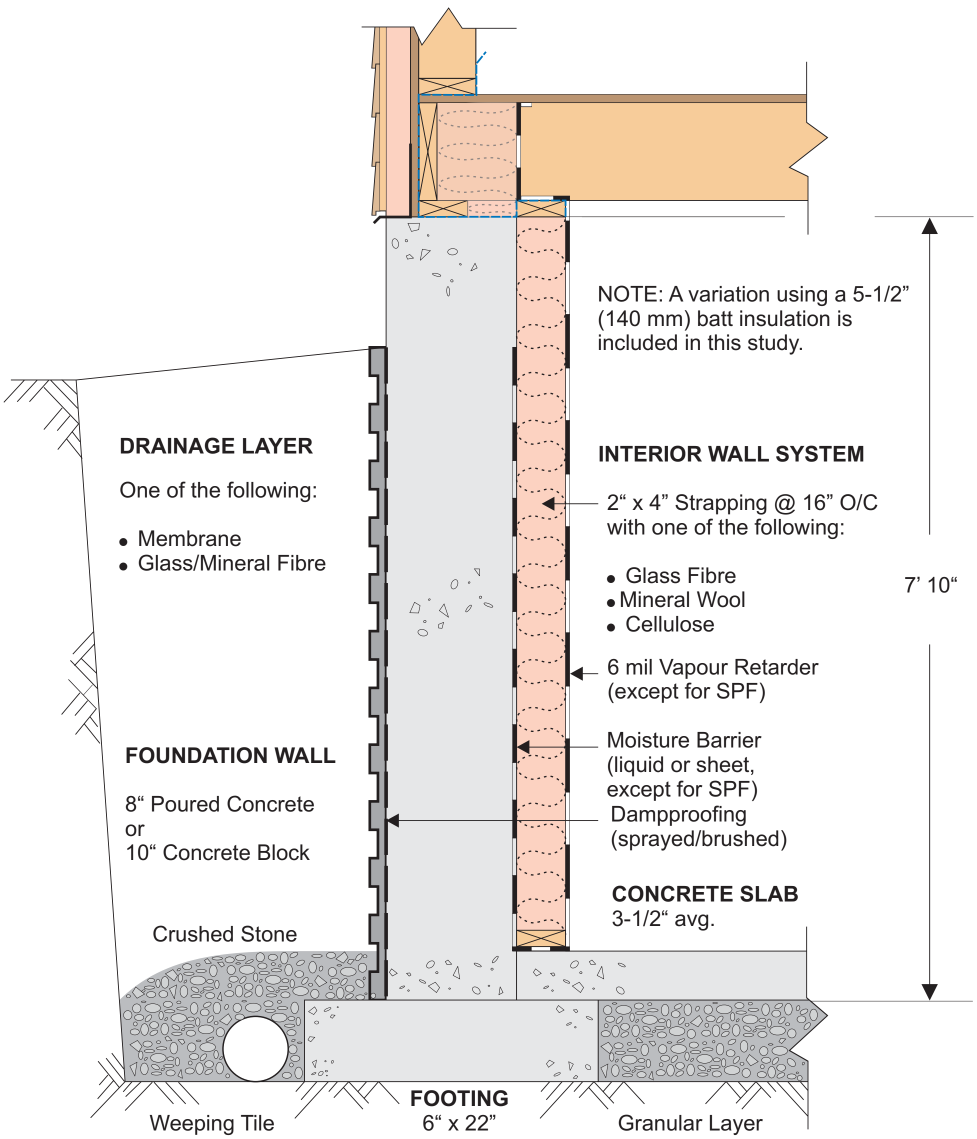

Figure 4. Basement system based on strapping and interior placement of thermal insulation.

Note: For higher levels of thermal insulation, the strapping is assumed to be offset from the interior surface of the foundation wall.

Another approach to the interior placement of thermal insulation is the use of plastic foam insulation panels fastened to the concrete wall, which are then protected against flamespread by gypsum drywall or a similar rated material. Figure 5 depicts the conventional arrangement of the materials within the assembly for this type of basement system, and also indicates a drainage layer, consistent with the system in Figure 4.

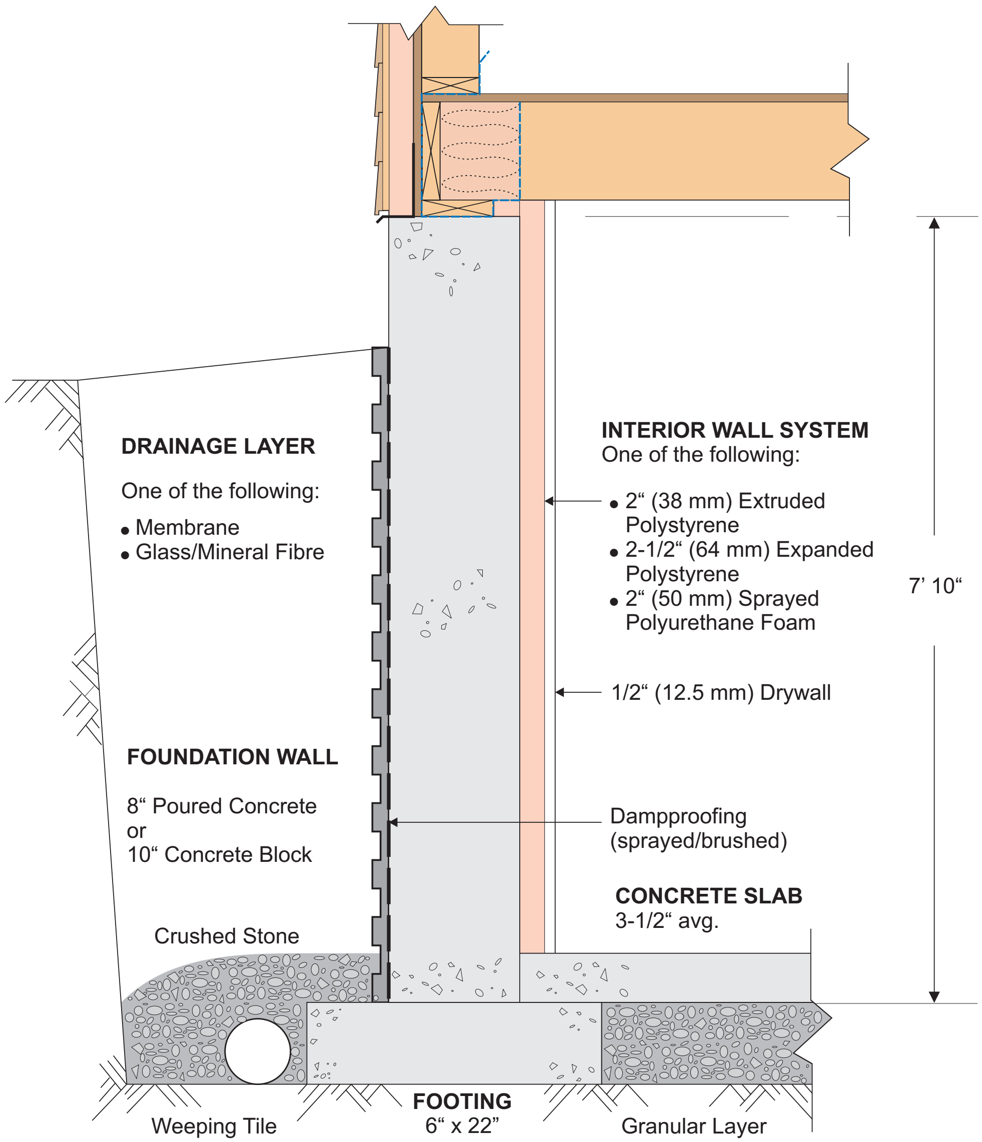

Figure 5. Basement system based on interior placement of plastic thermal insulation.

Figure 6 depicts an exterior insulation placement for the basement system. Exterior insulation schemes tend to involve the use of proprietary insulation systems, and remain confined to expanded and extruded polystyrene boards, rigid glass fibre or mineral wool panels, or sprayed polyurethane foam. Attachment of the board and panel type insulation to the foundation wall involves either the use of mechanical fasteners or a mastic-type adhesive. In the case of extruded polystyrene and sprayed polyurethane foam products, dampproofing of the foundation wall is not required. All systems require a suitable form of exterior protection of the exposed insulation, and when masonry veneers are used for upper floors, special details are required to preserve a marketable appearance of the dwelling. Heat loss modeling for this basement insulation option assumed above-grade claddings that permitted continuous insulation over the entire below and above grade wall area, as indicated below. However, a discussion of the energy impact of thermal bridging for exterior insulated basements supporting masonry veneer may be found on Page 54.

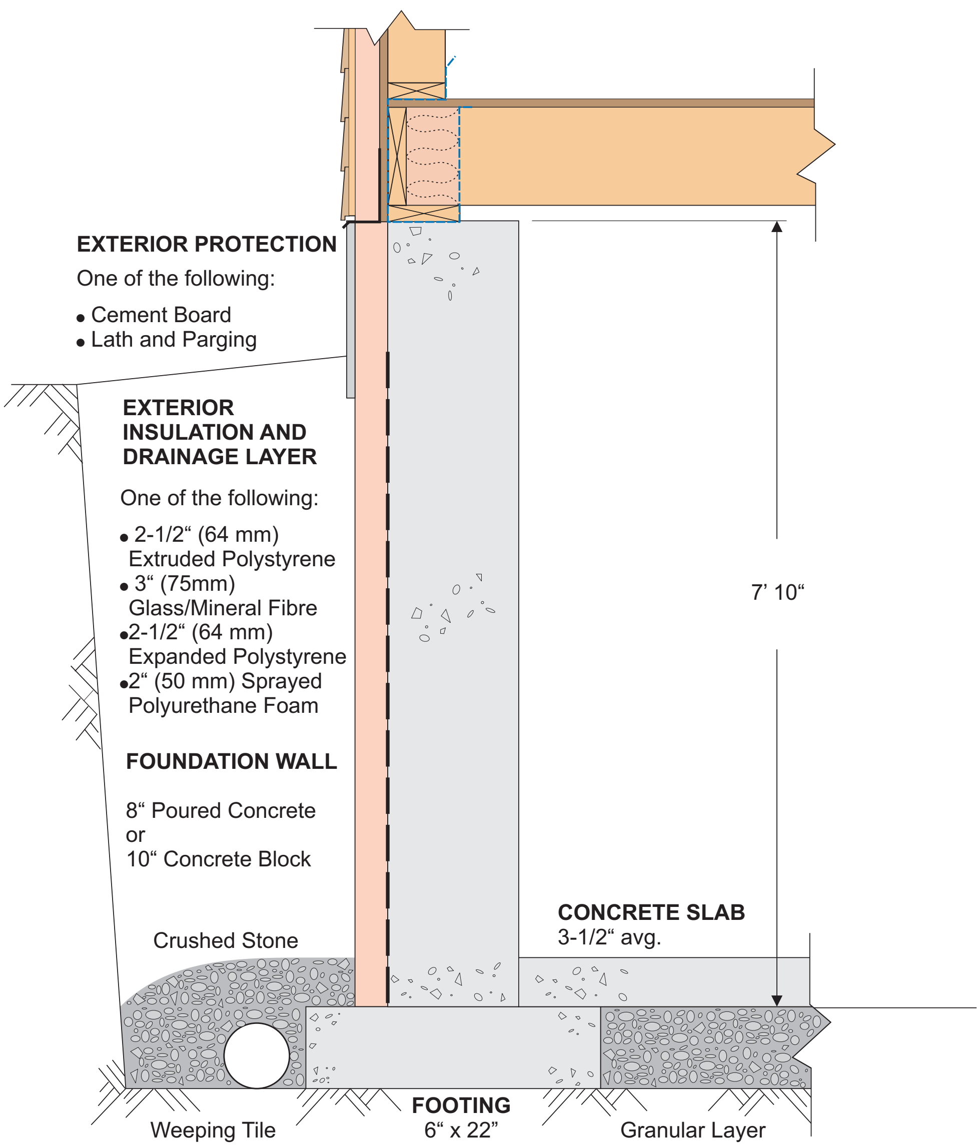

Figure 6. Basement system based on exterior placement of thermal insulation.

A relatively novel approach to the construction of basement systems is the use of insulated concrete forming systems (ICFs) as depicted in Figure 7. These pre-engineered, proprietary systems utilize expanded polystyrene forms to cast-in-place reinforced concrete which satisfies the structural requirements - the forms remain to provide thermal protection.   ICFs require exterior protection of the exposed insulation above-grade. Most ICFs incorporate special forms which permit the casting of supports for masonry veneers, however, the thermal bridging associated with these approaches tends to be similar to that discussed on Page 54. A foundation drainage layer is normally provided for these systems. On the interior of ICF system, the insulation (form) must be protected against flamespread by gypsum drywall or a similar rated material.

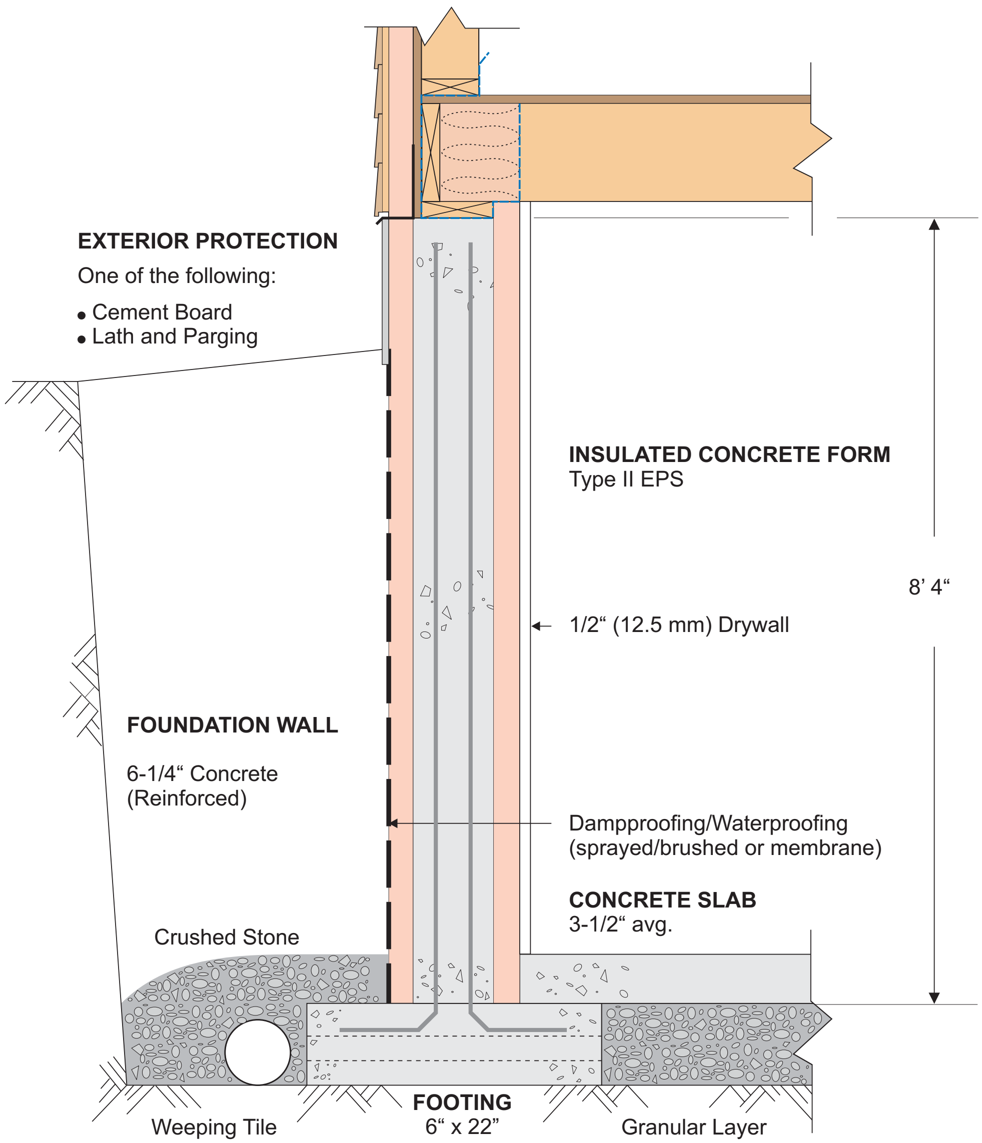

Figure 7. Basement system based on utilization of insulated concrete forms.

ICFs are normally used to construct the below and above-grade walls of residential buildings, and the isolation of the below-grade portion for this study cannot fully assess all of the benefits of a whole house system. It is important to note that heat loss modeling used in this study is not as illustrated above and assumes there is no thermal bridging at the basement wall and exterior wall intersection (i.e., ICF walls below and above grade).

BaseCalc™ – Basement Heat Loss Analysis Software

Version 1.0e of BaseCalc™ software was used to perform all operating energy simulations. Documentation on the technical features of BaseCalc is available from Natural Resources Canada (CANMET) and published literature.[1] Using the National Research Council of Canada's Mitalas method as a starting point, CANMET developed a new numerical technique to model basement and slab-on-grade heat losses. Version 1.0e of the BaseCalc performs a series of detailed finite-element calculations to estimate heat losses through residential foundations. The software can be used to assess the energy impact of new insulation placements and products, to develop building- and energy-code requirements, to perform research, and for developing improved foundation heat-loss models for whole-building simulation programs. BaseCalc has been applied in a number of code-related projects, including: an analysis of inside/outside "combination" insulation for the National Energy Code for Houses; a comparison of insulation options for the Ontario Building Code; and an analysis of insulation options for heated slabs for the National Energy Code for Houses.

Life Cycle Cost Assessment Method

The economic assessment method used in this study was derived from the *ASTM Standards on Building Economics*[2], and selected to reflect a 30 year study period, consistent with the timeframe selected within the National Energy Code for Houses. Life cycle costs are derived according to an ASTM method that recommends use of the modified uniform present worth formula.[3] Note that unlike the uniform present worth formula, the escalation rate of energy may be considered by the former method.

Modified Uniform Present Worth

$$P = A_{\circ} \cdot \left(\frac{1+e}{i-e}\right) \cdot \left[1 - \left(\frac{1+e}{1+i}\right)^{N}\right]$$

Uniform Present Worth

$$P = A \cdot \left(\frac{(1+i)^{N} - 1}{i\,(1+i)^{N}}\right)$$

where:

P = present sum of money.

A = end-of-period payment (or receipt) in a uniform series of payments (or receipts) over N periods at I interest or discount rate.

$A_{\circ}$ = initial value of a periodic payment (receipt) evaluated at the beginning of the study period.

N = number of interest or discount periods.

i = interest or discount rate.

e = price escalation rate per period.

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[1] I. Beausoleil-Morrison, *BASECALC™:A Software Tool for Modelling Residential-Foundation Heat Losses*, Proc. Third Canadian Conference on Computing in Civil and Building Engineering, Concordia University, Montréal Canada (1996) 117-126.

I. Beausoleil-Morrison, G.P. Mitalas, and H. Chin, *Estimating Three-Dimensional Below-Grade Heat Losses from Houses Using Two-Dimensional Calculations*, Proc. Thermal Performance of the Exterior Envelopes of Buildings VI, ASHRAE, Clearwater Beach USA, (1995) 95-99.

. Beausoleil-Morrison, G.P. Mitalas, and C. McLarnon, *BASECALC: New Software for Modelling Basement and Slab-on-Grade Heat Losses*, Proc. Building Simulation ‘95, International Building Performance Simulation Association, Madison, USA, (1995) 698-700.

[2] ASTM E 917, *Measuring Life-Cycle Costs of Buildings and Building Systems*, ASTM Standards on Building Economics, Fifth Edition, 2004.

[3] ASTM E 1185, *Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems*, ASTM Standards on Building Economics, Fifth Edition, 2004.

Sources of Information

In order to perform the analyses of the various basement insulation options considered in this study, the following data were collected and interpreted:

- Capital costs of basement systems and improvements.
- Builder carrying costs/profit margins.
- Energy prices and forecasts.

A large number of computer simulations were also performed using BaseCalc™ to determine the energy performance of the various basement systems in the following 5 geographic locations:

- Victoria, BC
- Edmonton AB
- Toronto ON
- Ottawa ON / Hull PQ
- Halifax NS

Commentary

In developing the basement models for this update study, readers should be aware of the following issues:

1. The base case scenario in the life cycle assessments is the Class C basement - an uninsulated basement with no explicit drainage layer. This base case violates the minimum standard, a Class B basement, which is enforced in many regions of Canada. However, because there are regions of Canada which permit the construction of Class C basements, this was deemed the effective minimum standard.

2. Much of the information used to compile basement system costs was gathered through builder surveys conducted in 1999. The sample size for the survey was limited by time and economic constraints, hence it cannot be considered statistically significant. In defence of this limitation, the scenarios were derived from a group of builders with decades of experience operating reputable and financially viable enterprises. Readers should note that while the costs of basement systems reported in this study may not be absolutely correct, they remain relatively correct such that the ranking of cost effectiveness is reasonably reliable.

Further and more specific commentary regarding related issues may be found in the parts of this report which follow.

COST DATA

Part 1 of this report outlines the objectives of this study. It is based on previous work conducted under the terms of the *Performance Guidelines for Basement Envelope Systems and Materials* project on behalf of the Institute for Research in Construction, National Research Council Canada. For a detailed description of the original study methodology, see:
http://irc.nrc-cnrc.gc.ca/pubs/rr/rr199/part6.pdf

It is important to note several key differences between the former study and this current update:

1. The cost of basement finishing is not considered in this study, with only the Class A-3 basement being considered due to the wide regional variations in basement finishing costs that could not be accurately reflected in this limited update.
2. The total basement system costs and their corresponding annual energy demands and operating costs have been summarized within the life cycle cost assessment tables by fuel type, rather than disaggregating thie data over a number of separate tables. This approach was taken in response to comments made by users of the earlier study.
3. The life cycle assessments employ three future scenarios. Two of these indicate an energy escalation rate that is higher than the discount rate, reflecting the current and expected relationship of energy costs to general inflation. This is seen to better reflect the likely future cost structures for energy prices over the 30 year study period used in the life cycle assessments. It is important to recognize that the low scenario speaks to a former era when energy price escalations were well below the interest or discount rates, and it is highly unlikely this situation will reoccur.

Sources of Information

To perform the assessment of the various economic scenarios, a number of sources of information were either referenced from the 1999 study or updates in early 2006.

Material Cost Survey

A limited survey was performed during February 2006 in the Toronto area to obtain prices for the various materials comprising the basement systems considered in this study. For some materials (e.g., sprayed-in-place insulation) quotes for material and labour were obtained from qualified contractors since this reflects normal practice. For validation purposes, the material was then summarized into unit costs which could easily be checked by users of this study.

Builder Survey

The 1999 survey administered to a cross-section of 8 builders in Ontario was referenced as a baseline and these costs were subsequently adjusted using construction price index data from Statistics Canada for each of the regions. The current prices for thermal/moisture protection options were added to the adjusted basement structure costs, and then a 12% margin was applied for taxes and profit derive 2006 basement system costs.

Energy Pricing

Energy pricing used in the assessment of life cycle operating costs, and energy pricing forecasts were obtained through Natural Resources Canada, Statistics Canada and fuel energy associations. Regional costs and forecasts were utilized where applicable.

Construction Cost Data

Costs derived for Ontario basement construction in Ontario were adjusted for other parts of Canada using data published in *Residential Cost Data* by the R.S. Means Co. This source of information has been used in a number of similar studies and has proven acceptable to stakeholders and reviewers.

Energy Prices and Construction Price Indices

Energy and construction prices have risen sharply since 1999. Table 2 summarizes the data employed in the current update study. It should be noted, by comparing with the 1999 energy prices listed in Table 3, that the cost of fossil fuels has increased more dramatically than construction costs during this period.

	Energy Price ($/GJ) February 2006				Location	1999-2005 Construction
	Gas	Oil	Propane	Electricity	Factor	Inflation
Toronto	15.01	21.57	29.25	26.67	1.14	135.2%
Ottawa	15.01	22.09	28.85	26.67	1.11	156.5%
Halifax	N/A	23.14	40.71	29.44	0.98	129.7%
Edmonton	7.21	20.29	20.95	27.50	1.01	148.6%
Victoria	15.40	23.53	28.46	19.36	1.07	117.0%
					Avg.	137.4%

Table 2. Energy prices, location factors and construction inflation for selected study locations.

	ENERGY PRICE ($/GJ) 1999			
	Gas	Oil	Propane	Electricity
Toronto	6.98	9.76	16.42	25.64
Ottawa	6.98	9.76	16.42	20.44
Halifax	N/A	9.47	18.34	26.11
Edmonton	4.64	7.97	13.09	20.86
Victoria*	6.98	10.56	16.83	17.00

Table 3. Energy prices used in original 1999 study.

The life cycle cost parameters employed in the analyses are summarized in Table 4. As noted previously, the low future energy cost scenario is more of an historical datum, unlikely to be seen in a world energy market of depleting resources. The high scenario reflects the situation where current energy prices in Canada begin to approach prices in other developed countries.

	Future Scenarios		
Parameter	***Low***	***Current***	***High***
Interest or Discount Rate	**2.0%**	**3.0%**	**5.0%**
Energy Escalation Rate	**4.0%**	**7.0%**	**12.0%**
Study Period (years)	**30**	**30**	**30**

Table 4. Life cycle cost parameters used in 2006 study.

These cost data along with the BASECALC™ space heating energy simulation results are subsequently applied within the life cycle cost analyses which follow.

LIFE CYCLE COST ASSESSMENTS

Life cycle cost assessments for each of the five locations (Toronto, Ottawa, Halifax, Edmonton, Victoria) are presented in the following sections of this report. The small basement data is presented first, followed by the large basement assessments. Detailed discussions of the analyses accompany each location, and are further broken down by fuel type. Based on an overview of all the analyses, there are several interesting relationships that have emerged since the 1999 study was conducted.

1. The assumption made in the original study that measures that were cost effective in a small basement would be even more cost effective in a larger basement has been proven correct. The life cycle cost per unit floor area for large basement systems is lower than for small basements because for simple basement geometries, the basement envelope area does not increase linearly with floor area.
2. In all locations, irrespective of the thermal/moisture protection option selected, Class A-3 basements (full-height insulation with proper moisture protection) delivered the lowest energy and total life cycle costs. Class B basements (partial-height insulation) and Class C basements (uninsulated cellars) are not cost effective to consumers of housing under any energy pricing scenario.
3. For all types and sizes of basements assessed in this study, the lowest life cycle energy cost was associated with basements constructed using insulating concrete forms (ICFs).
4. For all types and sizes of basements assessed in this study, the lowest total life cycle cost was associated with basements insulated internally, full-height to a nominal level of R-20 (RSI 3.52).
5. Where thermal bridging at the basement wall and floor header intersection is controlled, the annual energy demand and operating energy costs for externally versus internally insulated basements are practically equivalent. Life cycle costs for externally insulated basements are marginally higher than basements internally insulated to the same nominal thermal resistance. The difference is largely due to the higher installed cost of external insulation.
6. In basements with exterior insulation supporting masonry veneer, thermal bridging effects at the basement wall and floor header intersection are significant, resulting on average in a 20% increase in the annual energy demand and operating energy costs over the corresponding case where thermal bridging is controlled. This study did not examine a complete floor slab and wall system insulation wrap strategy, but for basements heated with in-floor hydronic systems, the control of thermal bridging may prove to be a critical practice for life cycle cost effectiveness.
7. There is considerable justification for reviewing the cost effective levels of thermal insulation for basement systems in regulatory codes and standards governing residential energy efficiency in Canada due to the sharp escalation in energy prices recently experienced and forecasts of the continuation of this trend well into the foreseeable future.

TORONTO – Small Basement Life Cycle Cost Assessments

Life cycle cost assessments for the Toronto small basement model are summarized in Tables 5 through 8, for natural gas, oil, propane and electricity, respectively. Based on fuel type, natural gas provides the lowest life cycle costs and propane yields the highest life cycle costs. The future of electricity pricing in Ontario remains speculative and while it currently shares second rank in terms of cost effectiveness, this situation may change dramatically within the next few years.

Toronto - Natural Gas 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	9.9	$13,848	$186	**$7,636**	**$10,614**	**$17,630**	**$21,484**	**$24,462**	**$31,477**
Ext Fibre	9.9	10.9	$13,409	$205	**$8,408**	**$11,686**	**$19,411**	**$21,817**	**$25,096**	**$32,820**
Ext EPS	11.25	10.5	$13,225	$197	**$8,099**	**$11,257**	**$18,698**	**$21,324**	**$24,482**	**$31,923**
Ext SPF	12	9.9	$14,631	$186	**$7,636**	**$10,614**	**$17,630**	**$22,268**	**$25,246**	**$32,261**
Int. Fibre	12	9.8	$12,711	$184	**$7,559**	**$10,507**	**$17,452**	**$20,270**	**$23,218**	**$30,163**
Int. Cell.	12	9.8	$12,770	$184	**$7,559**	**$10,507**	**$17,452**	**$20,329**	**$23,277**	**$30,222**
Int. Batt	20	8.2	$12,975	$154	**$6,325**	**$8,791**	**$14,603**	**$19,300**	**$21,766**	**$27,578**
Int. XPS	10	10.6	$14,176	$199	**$8,176**	**$11,365**	**$18,876**	**$22,352**	**$25,541**	**$33,053**
Int. EPS	9	10.8	$13,666	$203	**$8,330**	**$11,579**	**$19,233**	**$21,996**	**$25,245**	**$32,899**
Int. SPF	12	9.8	$15,534	$184	**$7,559**	**$10,507**	**$17,452**	**$23,093**	**$26,041**	**$32,986**
ICFs	22	7.7	$17,692	$144	**$5,939**	**$8,255**	**$13,712**	**$23,631**	**$25,947**	**$31,404**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	13.5	$10,153	$253	**$10,413**	**$14,474**	**$24,041**	**$20,566**	**$24,627**	**$34,194**
Int. Cell.	12	13.5	$10,179	$253	**$10,413**	**$14,474**	**$24,041**	**$20,592**	**$24,652**	**$34,219**
Int. Batt	20	12.5	$10,267	$235	**$9,642**	**$13,402**	**$22,260**	**$19,909**	**$23,668**	**$32,527**
Int. XPS	10	13.9	$10,784	$261	**$10,722**	**$14,903**	**$24,753**	**$21,506**	**$25,687**	**$35,537**
Int. EPS	9	14.1	$10,565	$265	**$10,876**	**$15,117**	**$25,109**	**$21,440**	**$25,682**	**$35,674**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	28.6	$9,355	$537	**$22,060**	**$30,663**	**$50,931**	**$31,416**	**$40,018**	**$60,286**

Table 5. Life cycle cost assessment of small basement in Toronto – 80% efficiency natural gas.

The maximum life cycle costs for each class of basement are denoted by grey shaded values, and the minimum values are denoted by white numbers in black shaded cells. In all cases, the Class A-3 basement system is the most cost effective under all future energy cost scenarios, when compared to a lower class of basement employing the same thermal/moisture protection option. The difference in annual energy costs between the best and worst performing Class A-3 basement is $61 (*ICFs* vs *Ext. Fibre*). For Class A-3 basements, the most energy efficient system is ICFs, and the most cost effective system utilizes internal fibre batt insulation with a nominal thermal resistance of R-20 (RSI 3.52). Among the Class A-3 basements, the highest life cycle cost systems vary depending on the energy price escalation scenario. When energy price escalations are low, the ICF option incurs the highest life cycle basement system cost because the life cycle energy savings do not offset the higher installed cost. Under the current energy price escalation scenario, the interior spray polyurethane foam insulation system incurs the highest life cycle basement system cost because the R-12 (RSI 2.11) insulation level is suboptimal relative to its installed cost. In the case of the high energy price escalation scenario, the internal extruded polystyrene insulation system yields the highest life cycle basement system cost because the R-12 (RSI 2.11) insulation level is suboptimal relative to its installed cost.

Toronto - Oil 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	9.9	$13,848	$267	**$10,974**	**$15,253**	**$25,335**	**$24,821**	**$29,100**	**$39,182**
Ext Fibre	9.9	10.9	$13,409	$294	**$12,082**	**$16,794**	**$27,894**	**$25,491**	**$30,203**	**$41,303**
Ext EPS	11.25	10.5	$13,225	$283	**$11,639**	**$16,177**	**$26,870**	**$24,863**	**$29,402**	**$40,095**
Ext SPF	12	9.9	$14,631	$267	**$10,974**	**$15,253**	**$25,335**	**$25,605**	**$29,884**	**$39,966**
Int. Fibre	12	9.8	$12,711	$264	**$10,863**	**$15,099**	**$25,079**	**$23,574**	**$27,810**	**$37,790**
Int. Cell.	12	9.8	$12,770	$264	**$10,863**	**$15,099**	**$25,079**	**$23,633**	**$27,869**	**$37,849**
Int. Batt	20	8.2	$12,975	$221	**$9,089**	**$12,634**	**$20,985**	**$22,064**	**$25,609**	**$33,960**
Int. XPS	10	10.6	$14,176	$286	**$11,749**	**$16,331**	**$27,126**	**$25,926**	**$30,507**	**$41,302**
Int. EPS	9	10.8	$13,666	$291	**$11,971**	**$16,639**	**$27,638**	**$25,637**	**$30,306**	**$41,304**
Int. SPF	12	9.8	$15,534	$264	**$10,863**	**$15,099**	**$25,079**	**$26,397**	**$30,633**	**$40,613**
ICFs	22	7.7	$17,692	$208	**$8,535**	**$11,863**	**$19,705**	**$26,227**	**$29,555**	**$37,397**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	13.5	$10,153	$364	**$14,964**	**$20,799**	**$34,548**	**$25,117**	**$30,953**	**$44,701**
Int. Cell.	12	13.5	$10,179	$364	**$14,964**	**$20,799**	**$34,548**	**$25,143**	**$30,978**	**$44,726**
Int. Batt	20	12.5	$10,267	$337	**$13,856**	**$19,259**	**$31,989**	**$24,122**	**$29,526**	**$42,255**
Int. XPS	10	13.9	$10,784	$375	**$15,407**	**$21,416**	**$35,571**	**$26,192**	**$32,200**	**$46,356**
Int. EPS	9	14.1	$10,565	$380	**$15,629**	**$21,724**	**$36,083**	**$26,194**	**$32,288**	**$46,648**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	28.6	$9,355	$771	**$31,701**	**$44,064**	**$73,190**	**$41,057**	**$53,419**	**$82,545**

Table 6. Life cycle cost assessment of small basement in Toronto – 80% efficiency oil.

Life cycle energy and basement system costs for basements heated with oil exhibit similar relationships as in the case of natural gas. With oil being a more expensive fuel than natural gas, the difference in annual energy costs between the best and worst performing Class A-3 basement, (*ICFs* vs *Ext. Fibre*) is $86.

An interesting relationship between energy price escalation scenarios for relatively expensive fuels is demonstrated in comparing *Int. SPF* versus *Int. EPS* for the Class A-3 basement. In the case of the low and current energy price escalation scenarios, the higher initial cost of the *Int. SPF* system is not recovered by life cycle energy savings. But under the high energy price escalation scenario, the lower installed cost of the *Int. EPS* system is outweighed by the higher life cycle energy costs. This indicates that paying a premium for a higher performance thermal/moisture protection option may be justified in the long term when energy price escalations are forecast to increase sharply.

Toronto - Propane 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	9.9	$13,848	$362	**$14,881**	**$20,684**	**$34,355**	**$28,728**	**$34,531**	**$48,203**
Ext Fibre	9.9	10.9	$13,409	$399	**$16,384**	**$22,773**	**$37,826**	**$29,793**	**$36,182**	**$51,235**
Ext EPS	11.25	10.5	$13,225	$384	**$15,783**	**$21,937**	**$36,438**	**$29,007**	**$35,162**	**$49,662**
Ext SPF	12	9.9	$14,631	$362	**$14,881**	**$20,684**	**$34,355**	**$29,512**	**$35,315**	**$48,987**
Int. Fibre	12	9.8	$12,711	$358	**$14,730**	**$20,475**	**$34,008**	**$27,441**	**$33,186**	**$46,720**
Int. Cell.	12	9.8	$12,770	$358	**$14,730**	**$20,475**	**$34,008**	**$27,500**	**$33,245**	**$46,778**
Int. Batt	20	8.2	$12,975	$300	**$12,325**	**$17,132**	**$28,456**	**$25,300**	**$30,107**	**$41,431**
Int. XPS	10	10.6	$14,176	$388	**$15,933**	**$22,146**	**$36,785**	**$30,109**	**$36,322**	**$50,961**
Int. EPS	9	10.8	$13,666	$395	**$16,233**	**$22,564**	**$37,479**	**$29,900**	**$36,230**	**$51,145**
Int. SPF	12	9.8	$15,534	$358	**$14,730**	**$20,475**	**$34,008**	**$30,264**	**$36,009**	**$49,542**
ICFs	22	7.7	$17,692	$282	**$11,574**	**$16,087**	**$26,721**	**$29,266**	**$33,779**	**$44,413**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	13.5	$10,153	$494	**$20,292**	**$28,205**	**$46,848**	**$30,445**	**$38,358**	**$57,002**
Int. Cell.	12	13.5	$10,179	$494	**$20,292**	**$28,205**	**$46,848**	**$30,470**	**$38,384**	**$57,027**
Int. Batt	20	12.5	$10,267	$457	**$18,789**	**$26,116**	**$43,378**	**$29,056**	**$36,383**	**$53,645**
Int. XPS	10	13.9	$10,784	$508	**$20,893**	**$29,041**	**$48,236**	**$31,677**	**$39,825**	**$59,021**
Int. EPS	9	14.1	$10,565	$516	**$21,194**	**$29,458**	**$48,931**	**$31,758**	**$40,023**	**$59,495**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	28.6	$9,355	$1,046	**$42,989**	**$59,753**	**$99,249**	**$52,344**	**$69,108**	**$108,605**

Table 7. Life cycle cost assessment of small basement in Toronto – 80% efficiency propane.

The annual energy costs and life cycle cost relationships for propane are similar to oil. With propane being the most expensive energy source in Toronto, Ontario, the difference in annual energy costs between the best and worst performing Class A-3 basement is $117 (*ICFs* versus *Ext. Fibre*).

Due to the high cost off propane, the highest life cycle basement system costs vary widely according to the energy price escalation scenario. Small differences in annual operating energy costs are magnified by high fuel prices undergoing increasing energy price escalation scenarios.

As noted earlier, the externally insulated basement systems tend to be more expensive initially and provide marginally lower thermal performance than interior insulation systems for the same nominal insulation level. This may partially explain the predominance of internal insulation systems in basements for housing.

Toronto - Electricity 100% Efficiency, Small Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	9.9	$13,848	$264	**$10,855**	**$15,087**	**$25,060**	**$24,702**	**$28,935**	**$38,908**
Ext Fibre	9.9	10.9	$13,409	$291	**$11,951**	**$16,611**	**$27,591**	**$25,360**	**$30,021**	**$41,001**
Ext EPS	11.25	10.5	$13,225	$280	**$11,512**	**$16,002**	**$26,579**	**$24,737**	**$29,226**	**$39,804**
Ext SPF	12	9.9	$14,631	$264	**$10,855**	**$15,087**	**$25,060**	**$25,486**	**$29,719**	**$39,692**
Int. Fibre	12	9.8	$12,711	$261	**$10,745**	**$14,935**	**$24,807**	**$23,456**	**$27,646**	**$37,518**
Int. Cell.	12	9.8	$12,770	$261	**$10,745**	**$14,935**	**$24,807**	**$23,515**	**$27,705**	**$37,577**
Int. Batt	20	8.2	$12,975	$219	**$8,991**	**$12,497**	**$20,757**	**$21,966**	**$25,472**	**$33,732**
Int. XPS	10	10.6	$14,176	$283	**$11,622**	**$16,154**	**$26,832**	**$25,798**	**$30,330**	**$41,008**
Int. EPS	9	10.8	$13,666	$288	**$11,841**	**$16,459**	**$27,338**	**$25,507**	**$30,125**	**$41,004**
Int. SPF	12	9.8	$15,534	$261	**$10,745**	**$14,935**	**$24,807**	**$26,279**	**$30,469**	**$40,341**
ICFs	22	7.7	$17,692	$205	**$8,442**	**$11,735**	**$19,491**	**$26,134**	**$29,426**	**$37,183**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	13.5	$10,153	$360	**$14,802**	**$20,574**	**$34,173**	**$24,955**	**$30,727**	**$44,326**
Int. Cell.	12	13.5	$10,179	$360	**$14,802**	**$20,574**	**$34,173**	**$24,980**	**$30,752**	**$44,351**
Int. Batt	20	12.5	$10,267	$333	**$13,705**	**$19,050**	**$31,642**	**$23,972**	**$29,317**	**$41,908**
Int. XPS	10	13.9	$10,784	$371	**$15,240**	**$21,183**	**$35,185**	**$26,024**	**$31,968**	**$45,970**
Int. EPS	9	14.1	$10,565	$376	**$15,459**	**$21,488**	**$35,692**	**$26,024**	**$32,053**	**$46,256**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	28.6	$9,355	$763	**$31,357**	**$43,586**	**$72,396**	**$40,713**	**$52,941**	**$81,751**

Table 8. Life cycle cost assessment of small basement in Toronto – 100% efficiency electricity.

The life cycle analysis for small basements heated with electricity is virtually identical to the case for 80% efficiency oil. While it remains beyond the scope of this study, the recent introduction into Canada of thermal storage systems for heating that utilize lowest cost off peak electrical energy, deserves future assessment. This is a unique characteristic of electrical energy that does not apply to fossil fuels and thermal storage technology may prove highly cost effective in many regions of Canada.

OTTAWA – Small Basement Life Cycle Cost Assessments

Life cycle cost assessments for Ottawa are very similar to Toronto due to comparable energy price structures. Ottawa has a colder climate than Toronto (4,600 versus 3,650 Degree-Days Celsius), and this accounts for differences in predicted energy consumption. Prices for construction have also escalated more in Ottawa than Toronto since 1999, making the initial capital cost of basements somewhat higher than in Toronto. These factors tend to counter one another with the life cycle energy savings being offset by higher capital costs. Life cycle cost assessments for small basement systems located in Ottawa are presented in Tables 9 through 12.

Ottawa - Natural Gas 80% Efficiency, Small Basement

Basement		Annual	Capital	Annual	LCC of Energy			LCC of Basement System		
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	12.3	$14,617	$231	**$9,487**	**$13,187**	**$21,904**	**$24,105**	**$27,805**	**$36,521**
Ext Fibre	9.9	13.1	$14,206	$246	**$10,104**	**$14,045**	**$23,328**	**$24,310**	**$28,251**	**$37,534**
Ext EPS	11.25	12.4	$14,032	$233	**$9,565**	**$13,294**	**$22,082**	**$23,597**	**$27,327**	**$36,114**
Ext SPF	12	12.3	$15,354	$231	**$9,487**	**$13,187**	**$21,904**	**$24,841**	**$28,541**	**$37,258**
Int. Fibre	12	11.7	$13,550	$220	**$9,025**	**$12,544**	**$20,835**	**$22,574**	**$26,094**	**$34,385**
Int. Cell.	12	11.7	$13,605	$220	**$9,025**	**$12,544**	**$20,835**	**$22,630**	**$26,149**	**$34,440**
Int. Batt	20	9.8	$13,798	$184	**$7,559**	**$10,507**	**$17,452**	**$21,357**	**$24,304**	**$31,249**
Int. XPS	10	12.5	$14,926	$235	**$9,642**	**$13,402**	**$22,260**	**$24,568**	**$28,328**	**$37,186**
Int. EPS	9	12.8	$14,447	$240	**$9,873**	**$13,723**	**$22,794**	**$24,320**	**$28,170**	**$37,241**
Int. SPF	12	11.7	$16,202	$220	**$9,025**	**$12,544**	**$20,835**	**$25,226**	**$28,746**	**$37,037**
ICFs	22	9.3	$18,945	$174	**$7,173**	**$9,971**	**$16,561**	**$26,118**	**$28,916**	**$35,506**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	16.0	$11,627	$300	**$12,341**	**$17,154**	**$28,493**	**$23,968**	**$28,781**	**$40,120**
Int. Cell.	12	16.0	$11,652	$300	**$12,341**	**$17,154**	**$28,493**	**$23,994**	**$28,807**	**$40,145**
Int. Batt	20	14.8	$11,741	$278	**$11,416**	**$15,867**	**$26,356**	**$23,157**	**$27,608**	**$38,097**
Int. XPS	10	16.5	$12,258	$310	**$12,727**	**$17,690**	**$29,383**	**$24,985**	**$29,948**	**$41,641**
Int. EPS	9	16.7	$12,038	$313	**$12,881**	**$17,905**	**$29,739**	**$24,920**	**$29,943**	**$41,778**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	33.3	$10,829	$625	**$25,685**	**$35,702**	**$59,301**	**$36,515**	**$46,531**	**$70,130**

Table 9. Life cycle cost assessment of small basement in Ottawa – 80% efficiency natural gas.

Ottawa - Oil 80% Efficiency, Small Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	12.3	$14,617	$340	**$13,962**	**$19,407**	**$32,236**	**$28,580**	**$34,025**	**$46,853**
Ext Fibre	9.9	13.1	$14,206	$362	**$14,871**	**$20,670**	**$34,332**	**$29,076**	**$34,875**	**$48,538**
Ext EPS	11.25	12.4	$14,032	$342	**$14,076**	**$19,565**	**$32,498**	**$28,108**	**$33,597**	**$46,530**
Ext SPF	12	12.3	$15,354	$340	**$13,962**	**$19,407**	**$32,236**	**$29,316**	**$34,761**	**$47,589**
Int. Fibre	12	11.7	$13,550	$323	**$13,281**	**$18,461**	**$30,663**	**$26,831**	**$32,010**	**$44,213**
Int. Cell.	12	11.7	$13,605	$323	**$13,281**	**$18,461**	**$30,663**	**$26,886**	**$32,066**	**$44,268**
Int. Batt	20	9.8	$13,798	$271	**$11,125**	**$15,463**	**$25,684**	**$24,922**	**$29,260**	**$39,481**
Int. XPS	10	12.5	$14,926	$345	**$14,190**	**$19,723**	**$32,760**	**$29,116**	**$34,649**	**$47,686**
Int. EPS	9	12.8	$14,447	$353	**$14,530**	**$20,196**	**$33,546**	**$28,977**	**$34,643**	**$47,993**
Int. SPF	12	11.7	$16,202	$323	**$13,281**	**$18,461**	**$30,663**	**$29,483**	**$34,662**	**$46,865**
ICFs	22	9.3	$18,945	$257	**$10,557**	**$14,674**	**$24,373**	**$29,502**	**$33,619**	**$43,318**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	16.0	$11,627	$442	**$18,163**	**$25,245**	**$41,932**	**$29,790**	**$36,872**	**$53,560**
Int. Cell.	12	16.0	$11,652	$442	**$18,163**	**$25,245**	**$41,932**	**$29,815**	**$36,898**	**$53,585**
Int. Batt	20	14.8	$11,741	$409	**$16,800**	**$23,352**	**$38,788**	**$28,541**	**$35,093**	**$50,528**
Int. XPS	10	16.5	$12,258	$456	**$18,730**	**$26,034**	**$43,243**	**$30,988**	**$38,292**	**$55,501**
Int. EPS	9	16.7	$12,038	$461	**$18,957**	**$26,350**	**$43,767**	**$30,996**	**$38,388**	**$55,806**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	33.3	$10,829	$919	**$37,801**	**$52,542**	**$87,272**	**$48,630**	**$63,371**	**$98,101**

Table 10. Life cycle cost assessment of small basement in Ottawa – 80% efficiency oil.

Ottawa - Propane 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	12.3	$14,617	$444	**$18,235**	**$25,346**	**$42,100**	**$32,853**	**$39,964**	**$56,718**
Ext Fibre	9.9	13.1	$14,206	$472	**$19,421**	**$26,995**	**$44,839**	**$33,627**	**$41,201**	**$59,044**
Ext EPS	11.25	12.4	$14,032	$447	**$18,384**	**$25,552**	**$42,443**	**$32,416**	**$39,585**	**$56,475**
Ext SPF	12	12.3	$15,354	$444	**$18,235**	**$25,346**	**$42,100**	**$33,589**	**$40,700**	**$57,454**
Int. Fibre	12	11.7	$13,550	$422	**$17,346**	**$24,110**	**$40,047**	**$30,895**	**$37,660**	**$53,596**
Int. Cell.	12	11.7	$13,605	$422	**$17,346**	**$24,110**	**$40,047**	**$30,951**	**$37,715**	**$53,652**
Int. Batt	20	9.8	$13,798	$353	**$14,529**	**$20,195**	**$33,543**	**$28,327**	**$33,992**	**$47,341**
Int. XPS	10	12.5	$14,926	$451	**$18,532**	**$25,759**	**$42,785**	**$33,458**	**$40,685**	**$57,711**
Int. EPS	9	12.8	$14,447	$462	**$18,977**	**$26,377**	**$43,812**	**$33,423**	**$40,824**	**$58,259**
Int. SPF	12	11.7	$16,202	$422	**$17,346**	**$24,110**	**$40,047**	**$33,547**	**$40,312**	**$56,248**
ICFs	22	9.3	$18,945	$335	**$13,788**	**$19,164**	**$31,832**	**$32,732**	**$38,109**	**$50,777**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	16.0	$11,627	$577	**$23,721**	**$32,971**	**$54,765**	**$35,348**	**$44,598**	**$66,392**
Int. Cell.	12	16.0	$11,652	$577	**$23,721**	**$32,971**	**$54,765**	**$35,373**	**$44,623**	**$66,417**
Int. Batt	20	14.8	$11,741	$534	**$21,942**	**$30,498**	**$50,657**	**$33,682**	**$42,239**	**$62,398**
Int. XPS	10	16.5	$12,258	$595	**$24,462**	**$34,001**	**$56,476**	**$36,720**	**$46,259**	**$68,734**
Int. EPS	9	16.7	$12,038	$602	**$24,759**	**$34,413**	**$57,161**	**$36,797**	**$46,452**	**$69,199**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	33.3	$10,829	$1,201	**$49,369**	**$68,621**	**$113,979**	**$60,198**	**$79,450**	**$124,808**

Table 11. Life cycle cost assessment of small basement in Ottawa – 80% efficiency propane.

Ottawa - Electricity 100% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	12.3	$14,617	$328	**$13,486**	**$18,745**	**$31,135**	**$28,103**	**$33,362**	**$45,753**
Ext Fibre	9.9	13.1	$14,206	$349	**$14,363**	**$19,964**	**$33,160**	**$28,569**	**$34,170**	**$47,366**
Ext EPS	11.25	12.4	$14,032	$331	**$13,596**	**$18,897**	**$31,388**	**$27,628**	**$32,929**	**$45,421**
Ext SPF	12	12.3	$15,354	$328	**$13,486**	**$18,745**	**$31,135**	**$28,840**	**$34,099**	**$46,489**
Int. Fibre	12	11.7	$13,550	$312	**$12,828**	**$17,831**	**$29,616**	**$26,378**	**$31,380**	**$43,166**
Int. Cell.	12	11.7	$13,605	$312	**$12,828**	**$17,831**	**$29,616**	**$26,433**	**$31,436**	**$43,222**
Int. Batt	20	9.8	$13,798	$261	**$10,745**	**$14,935**	**$24,807**	**$24,542**	**$28,733**	**$38,605**
Int. XPS	10	12.5	$14,926	$333	**$13,705**	**$19,050**	**$31,642**	**$28,631**	**$33,976**	**$46,568**
Int. EPS	9	12.8	$14,447	$341	**$14,034**	**$19,507**	**$32,401**	**$28,481**	**$33,954**	**$46,848**
Int. SPF	12	11.7	$16,202	$312	**$12,828**	**$17,831**	**$29,616**	**$29,030**	**$34,032**	**$45,818**
ICFs	22	9.3	$18,945	$248	**$10,197**	**$14,173**	**$23,541**	**$29,141**	**$33,118**	**$42,486**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	16.0	$11,627	$427	**$17,543**	**$24,384**	**$40,501**	**$29,170**	**$36,011**	**$52,128**
Int. Cell.	12	16.0	$11,652	$427	**$17,543**	**$24,384**	**$40,501**	**$29,195**	**$36,036**	**$52,154**
Int. Batt	20	14.8	$11,741	$395	**$16,227**	**$22,555**	**$37,464**	**$27,968**	**$34,296**	**$49,204**
Int. XPS	10	16.5	$12,258	$440	**$18,091**	**$25,146**	**$41,767**	**$30,349**	**$37,404**	**$54,025**
Int. EPS	9	16.7	$12,038	$445	**$18,310**	**$25,450**	**$42,273**	**$30,349**	**$37,489**	**$54,312**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	33.3	$10,829	$888	**$36,511**	**$50,748**	**$84,293**	**$47,340**	**$61,578**	**$95,122**

Table 12. Life cycle cost assessment of small basement in Ottawa – 100% efficiency electricity.

HALIFAX – Small Basement Life Cycle Cost Assessments

Due to the unavailability of natural gas in Halifax, the lowest price fuel (oil) is significantly more expensive than the lowest priced fuel (natural gas) in all of the other study locations. When this factor is coupled to the Halifax climate (4,100 Degree-Days Celsius), basement operating costs are relatively high compared to other parts of Canada.

Halifax was estimated to have the lowest basement capital costs, but among the highest life cycle costs, signifying that Class A-3 basements (full-height insulation) represent a highly cost effective alternative to Class B and C basement systems. Life cycle cost assessments for small basement systems located in Halifax are presented in Tables 13 through 15.

Again, in all cases and for all fuel types, the Class A-3 basement system is the most cost effective under all future energy cost scenarios, when compared to a lower class of basement employing the same thermal/moisture protection option.

Halifax - Oil 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	11.8	$11,120	$341	**$14,032**	**$19,503**	**$32,395**	**$25,152**	**$30,623**	**$43,515**
Ext Fibre	9.9	12.6	$10,756	$364	**$14,983**	**$20,826**	**$34,591**	**$25,739**	**$31,582**	**$45,348**
Ext EPS	11.25	12.1	$10,603	$350	**$14,388**	**$19,999**	**$33,219**	**$24,992**	**$30,602**	**$43,822**
Ext SPF	12	11.8	$11,770	$341	**$14,032**	**$19,503**	**$32,395**	**$25,802**	**$31,274**	**$44,165**
Int. Fibre	12	11.3	$10,177	$327	**$13,437**	**$18,677**	**$31,022**	**$23,614**	**$28,854**	**$41,200**
Int. Cell.	12	11.3	$10,226	$327	**$13,437**	**$18,677**	**$31,022**	**$23,663**	**$28,903**	**$41,249**
Int. Batt	20	9.5	$10,396	$275	**$11,297**	**$15,702**	**$26,081**	**$21,693**	**$26,098**	**$36,477**
Int. XPS	10	12.1	$11,392	$350	**$14,388**	**$19,999**	**$33,219**	**$25,781**	**$31,392**	**$44,611**
Int. EPS	9	12.1	$10,969	$350	**$14,388**	**$19,999**	**$33,219**	**$25,358**	**$30,969**	**$44,188**
Int. SPF	12	11.3	$12,519	$327	**$13,437**	**$18,677**	**$31,022**	**$25,956**	**$31,196**	**$43,541**
ICFs	22	9.1	$14,145	$263	**$10,821**	**$15,041**	**$24,983**	**$24,966**	**$29,186**	**$39,128**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	15.4	$9,773	$445	**$18,312**	**$25,454**	**$42,278**	**$28,085**	**$35,226**	**$52,051**
Int. Cell.	12	15.4	$9,798	$445	**$18,312**	**$25,454**	**$42,278**	**$28,110**	**$35,252**	**$52,076**
Int. Batt	20	14.3	$9,886	$414	**$17,004**	**$23,635**	**$39,259**	**$26,891**	**$33,522**	**$49,145**
Int. XPS	10	15.8	$10,404	$457	**$18,788**	**$26,115**	**$43,377**	**$29,192**	**$36,518**	**$53,780**
Int. EPS	9	16.0	$10,184	$463	**$19,026**	**$26,445**	**$43,926**	**$29,210**	**$36,629**	**$54,110**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	31.3	$8,975	$905	**$37,219**	**$51,734**	**$85,930**	**$46,194**	**$60,708**	**$94,904**

Table 13. Life cycle cost assessment of small basement in Halifax – 80% efficiency oil.

Halifax - Propane 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	11.8	$11,120	$600	**$24,686**	**$34,312**	**$56,993**	**$35,806**	**$45,432**	**$68,112**
Ext Fibre	9.9	12.6	$10,756	$641	**$26,359**	**$36,638**	**$60,856**	**$37,116**	**$47,395**	**$71,613**
Ext EPS	11.25	12.1	$10,603	$616	**$25,313**	**$35,185**	**$58,441**	**$35,917**	**$45,788**	**$69,045**
Ext SPF	12	11.8	$11,770	$600	**$24,686**	**$34,312**	**$56,993**	**$36,456**	**$46,082**	**$68,763**
Int. Fibre	12	11.3	$10,177	$575	**$23,640**	**$32,858**	**$54,578**	**$33,817**	**$43,036**	**$64,755**
Int. Cell.	12	11.3	$10,226	$575	**$23,640**	**$32,858**	**$54,578**	**$33,866**	**$43,084**	**$64,804**
Int. Batt	20	9.5	$10,396	$483	**$19,874**	**$27,624**	**$45,884**	**$30,270**	**$38,020**	**$56,280**
Int. XPS	10	12.1	$11,392	$616	**$25,313**	**$35,185**	**$58,441**	**$36,706**	**$46,577**	**$69,834**
Int. EPS	9	12.1	$10,969	$616	**$25,313**	**$35,185**	**$58,441**	**$36,283**	**$46,154**	**$69,411**
Int. SPF	12	11.3	$12,519	$575	**$23,640**	**$32,858**	**$54,578**	**$36,158**	**$45,377**	**$67,096**
ICFs	22	9.1	$14,145	$463	**$19,037**	**$26,461**	**$43,952**	**$33,183**	**$40,606**	**$58,097**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	15.4	$9,773	$784	**$32,217**	**$44,780**	**$74,380**	**$41,990**	**$54,553**	**$84,153**
Int. Cell.	12	15.4	$9,798	$784	**$32,217**	**$44,780**	**$74,380**	**$42,015**	**$54,578**	**$84,178**
Int. Batt	20	14.3	$9,886	$728	**$29,916**	**$41,582**	**$69,067**	**$39,802**	**$51,468**	**$78,954**
Int. XPS	10	15.8	$10,404	$804	**$33,054**	**$45,943**	**$76,312**	**$43,457**	**$56,347**	**$86,716**
Int. EPS	9	16.0	$10,184	$814	**$33,472**	**$46,525**	**$77,278**	**$43,656**	**$56,709**	**$87,462**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	31.3	$8,975	$1,593	**$65,480**	**$91,015**	**$151,175**	**$74,455**	**$99,989**	**$160,150**

Table 14. Life cycle cost assessment of small basement in Halifax – 80% efficiency propane.

Halifax - Electricity 100% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	11.8	$11,120	$347	**$14,281**	**$19,851**	**$32,972**	**$25,401**	**$30,971**	**$44,092**
Ext Fibre	9.9	12.6	$10,756	$371	**$15,250**	**$21,196**	**$35,207**	**$26,006**	**$31,953**	**$45,964**
Ext EPS	11.25	12.1	$10,603	$356	**$14,645**	**$20,355**	**$33,810**	**$25,248**	**$30,959**	**$44,413**
Ext SPF	12	11.8	$11,770	$347	**$14,281**	**$19,851**	**$32,972**	**$26,052**	**$31,621**	**$44,742**
Int. Fibre	12	11.3	$10,177	$333	**$13,676**	**$19,010**	**$31,575**	**$23,854**	**$29,187**	**$41,752**
Int. Cell.	12	11.3	$10,226	$333	**$13,676**	**$19,010**	**$31,575**	**$23,902**	**$29,236**	**$41,801**
Int. Batt	20	9.5	$10,396	$280	**$11,498**	**$15,981**	**$26,545**	**$21,894**	**$26,378**	**$36,941**
Int. XPS	10	12.1	$11,392	$356	**$14,645**	**$20,355**	**$33,810**	**$26,037**	**$31,748**	**$45,203**
Int. EPS	9	12.1	$10,969	$356	**$14,645**	**$20,355**	**$33,810**	**$25,614**	**$31,325**	**$44,780**
Int. SPF	12	11.3	$12,519	$333	**$13,676**	**$19,010**	**$31,575**	**$26,195**	**$31,528**	**$44,094**
ICFs	22	9.1	$14,145	$268	**$11,014**	**$15,309**	**$25,428**	**$25,159**	**$29,454**	**$39,573**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	15.4	$9,773	$453	**$18,638**	**$25,907**	**$43,031**	**$28,411**	**$35,679**	**$52,804**
Int. Cell.	12	15.4	$9,798	$453	**$18,638**	**$25,907**	**$43,031**	**$28,436**	**$35,705**	**$52,829**
Int. Batt	20	14.3	$9,886	$421	**$17,307**	**$24,056**	**$39,958**	**$27,193**	**$33,943**	**$49,844**
Int. XPS	10	15.8	$10,404	$465	**$19,123**	**$26,580**	**$44,149**	**$29,526**	**$36,983**	**$54,553**
Int. EPS	9	16.0	$10,184	$471	**$19,365**	**$26,916**	**$44,708**	**$29,549**	**$37,100**	**$54,892**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	31.3	$8,975	$921	**$37,882**	**$52,655**	**$87,459**	**$46,857**	**$61,630**	**$96,434**

Table 15. Life cycle cost assessment of small basement in Halifax – 100% efficiency electricity.

EDMONTON – Small Basement Life Cycle Cost Assessments

Edmonton represents the coldest climate location in the study (5,400 Degree-Days Celsius), but the lowest energy prices. To put this relationship into a simple perspective, Edmonton is similar to Toronto in terms of the cost effectiveness of full-height basement insulation. In all cases and across all fuel types, the Class A-3 basement system is the most cost effective under all future energy cost scenarios, when compared to a lower class of basement employing the same thermal/moisture protection option. Life cycle cost assessments for small basement systems located in Edmonton are presented in Tables 16 through 19.

Edmonton - Natural Gas 80% Efficiency, Small Basement

Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	15.2	$12,758	$137	**$5,632**	**$7,828**	**$13,002**	**$18,390**	**$20,586**	**$25,760**
Ext Fibre	9.9	16.1	$12,383	$145	**$5,965**	**$8,291**	**$13,772**	**$18,349**	**$20,675**	**$26,155**
Ext EPS	11.25	15.5	$12,226	$140	**$5,743**	**$7,982**	**$13,259**	**$17,968**	**$20,208**	**$25,484**
Ext SPF	12	15.2	$13,428	$137	**$5,632**	**$7,828**	**$13,002**	**$19,060**	**$21,256**	**$26,430**
Int. Fibre	12	14.5	$11,787	$131	**$5,372**	**$7,467**	**$12,403**	**$17,159**	**$19,254**	**$24,190**
Int. Cell.	12	14.5	$11,837	$131	**$5,372**	**$7,467**	**$12,403**	**$17,209**	**$19,304**	**$24,240**
Int. Batt	20	12.3	$12,012	$111	**$4,557**	**$6,334**	**$10,521**	**$16,569**	**$18,347**	**$22,534**
Int. XPS	10	15.4	$13,039	$139	**$5,706**	**$7,931**	**$13,173**	**$18,745**	**$20,970**	**$26,212**
Int. EPS	9	15.8	$12,603	$142	**$5,854**	**$8,137**	**$13,515**	**$18,457**	**$20,740**	**$26,118**
Int. SPF	12	14.5	$14,200	$131	**$5,372**	**$7,467**	**$12,403**	**$19,572**	**$21,667**	**$26,603**
ICFs	22	11.6	$16,454	$105	**$4,298**	**$5,974**	**$9,923**	**$20,752**	**$22,428**	**$26,377**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.5	$11,080	$176	**$7,225**	**$10,042**	**$16,680**	**$18,305**	**$21,123**	**$27,761**
Int. Cell.	12	19.5	$11,106	$176	**$7,225**	**$10,042**	**$16,680**	**$18,331**	**$21,148**	**$27,786**
Int. Batt	20	18.1	$11,194	$163	**$6,706**	**$9,321**	**$15,483**	**$17,900**	**$20,515**	**$26,677**
Int. XPS	10	20.1	$11,712	$181	**$7,447**	**$10,351**	**$17,194**	**$19,159**	**$22,063**	**$28,905**
Int. EPS	9	20.3	$11,492	$183	**$7,521**	**$10,454**	**$17,365**	**$19,013**	**$21,946**	**$28,856**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	39.7	$10,283	$358	**$14,709**	**$20,445**	**$33,959**	**$24,992**	**$30,728**	**$44,242**

Table 16. Life cycle cost assessment of small basement in Edmonton – 80% efficiency natural gas.

Edmonton - Oil 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	15.2	$12,758	$386	**$15,848**	**$22,029**	**$36,590**	**$28,607**	**$34,787**	**$49,348**
Ext Fibre	9.9	16.1	$12,383	$408	**$16,787**	**$23,333**	**$38,756**	**$29,170**	**$35,717**	**$51,140**
Ext EPS	11.25	15.5	$12,226	$393	**$16,161**	**$22,464**	**$37,312**	**$28,387**	**$34,689**	**$49,538**
Ext SPF	12	15.2	$13,428	$386	**$15,848**	**$22,029**	**$36,590**	**$29,277**	**$35,457**	**$50,018**
Int. Fibre	12	14.5	$11,787	$368	**$15,119**	**$21,014**	**$34,905**	**$26,905**	**$32,801**	**$46,691**
Int. Cell.	12	14.5	$11,837	$368	**$15,119**	**$21,014**	**$34,905**	**$26,956**	**$32,851**	**$46,742**
Int. Batt	20	12.3	$12,012	$312	**$12,825**	**$17,826**	**$29,609**	**$24,837**	**$29,838**	**$41,621**
Int. XPS	10	15.4	$13,039	$391	**$16,057**	**$22,319**	**$37,071**	**$29,096**	**$35,358**	**$50,110**
Int. EPS	9	15.8	$12,603	$401	**$16,474**	**$22,898**	**$38,034**	**$29,077**	**$35,501**	**$50,637**
Int. SPF	12	14.5	$14,200	$368	**$15,119**	**$21,014**	**$34,905**	**$29,318**	**$35,214**	**$49,104**
ICFs	22	11.6	$16,454	$294	**$12,095**	**$16,811**	**$27,924**	**$28,549**	**$33,265**	**$44,378**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.5	$11,080	$495	**$20,332**	**$28,261**	**$46,941**	**$31,412**	**$39,341**	**$58,021**
Int. Cell.	12	19.5	$11,106	$495	**$20,332**	**$28,261**	**$46,941**	**$31,438**	**$39,366**	**$58,047**
Int. Batt	20	18.1	$11,194	$459	**$18,872**	**$26,232**	**$43,571**	**$30,066**	**$37,426**	**$54,765**
Int. XPS	10	20.1	$11,712	$510	**$20,958**	**$29,130**	**$48,385**	**$32,669**	**$40,842**	**$60,097**
Int. EPS	9	20.3	$11,492	$515	**$21,166**	**$29,420**	**$48,867**	**$32,658**	**$40,912**	**$60,359**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	39.7	$10,283	$1,007	**$41,394**	**$57,536**	**$95,567**	**$51,676**	**$67,818**	**$105,850**

Table 17. Life cycle cost assessment of small basement in Edmonton – 80% efficiency oil.

Edmonton - Propane 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	15.2	$12,758	$398	**$16,364**	**$22,745**	**$37,780**	**$29,122**	**$35,503**	**$50,538**
Ext Fibre	9.9	16.1	$12,383	$422	**$17,333**	**$24,092**	**$40,017**	**$29,716**	**$36,476**	**$52,400**
Ext EPS	11.25	15.5	$12,226	$406	**$16,687**	**$23,194**	**$38,526**	**$28,913**	**$35,420**	**$50,751**
Ext SPF	12	15.2	$13,428	$398	**$16,364**	**$22,745**	**$37,780**	**$29,792**	**$36,174**	**$51,208**
Int. Fibre	12	14.5	$11,787	$380	**$15,610**	**$21,698**	**$36,040**	**$27,397**	**$33,484**	**$47,827**
Int. Cell.	12	14.5	$11,837	$380	**$15,610**	**$21,698**	**$36,040**	**$27,447**	**$33,535**	**$47,877**
Int. Batt	20	12.3	$12,012	$322	**$13,242**	**$18,406**	**$30,572**	**$25,254**	**$30,418**	**$42,584**
Int. XPS	10	15.4	$13,039	$403	**$16,579**	**$23,045**	**$38,277**	**$29,618**	**$36,084**	**$51,316**
Int. EPS	9	15.8	$12,603	$414	**$17,010**	**$23,643**	**$39,271**	**$29,613**	**$36,246**	**$51,874**
Int. SPF	12	14.5	$14,200	$380	**$15,610**	**$21,698**	**$36,040**	**$29,810**	**$35,898**	**$50,240**
ICFs	22	11.6	$16,454	$304	**$12,488**	**$17,358**	**$28,832**	**$28,942**	**$33,812**	**$45,286**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.5	$11,080	$511	**$20,993**	**$29,180**	**$48,468**	**$32,074**	**$40,260**	**$59,548**
Int. Cell.	12	19.5	$11,106	$511	**$20,993**	**$29,180**	**$48,468**	**$32,099**	**$40,286**	**$59,574**
Int. Batt	20	18.1	$11,194	$474	**$19,486**	**$27,085**	**$44,988**	**$30,680**	**$38,279**	**$56,182**
Int. XPS	10	20.1	$11,712	$526	**$21,639**	**$30,078**	**$49,959**	**$33,351**	**$41,789**	**$61,671**
Int. EPS	9	20.3	$11,492	$532	**$21,855**	**$30,377**	**$50,456**	**$33,346**	**$41,869**	**$61,948**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	39.7	$10,283	$1,040	**$42,740**	**$59,407**	**$98,676**	**$53,023**	**$69,690**	**$108,958**

Table 18. Life cycle cost assessment of small basement in Edmonton – 80% efficiency propane.

Edmonton - Electricity 100% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	15.2	$12,758	$418	**$17,184**	**$23,885**	**$39,674**	**$29,942**	**$36,643**	**$52,432**
Ext Fibre	9.9	16.1	$12,383	$443	**$18,202**	**$25,300**	**$42,023**	**$30,585**	**$37,683**	**$54,406**
Ext EPS	11.25	15.5	$12,226	$426	**$17,523**	**$24,357**	**$40,457**	**$29,749**	**$36,582**	**$52,682**
Ext SPF	12	15.2	$13,428	$418	**$17,184**	**$23,885**	**$39,674**	**$30,612**	**$37,314**	**$53,102**
Int. Fibre	12	14.5	$11,787	$399	**$16,393**	**$22,785**	**$37,846**	**$28,179**	**$34,572**	**$49,633**
Int. Cell.	12	14.5	$11,837	$399	**$16,393**	**$22,785**	**$37,846**	**$28,230**	**$34,622**	**$49,683**
Int. Batt	20	12.3	$12,012	$338	**$13,906**	**$19,328**	**$32,104**	**$25,918**	**$31,340**	**$44,116**
Int. XPS	10	15.4	$13,039	$424	**$17,410**	**$24,200**	**$40,196**	**$30,449**	**$37,239**	**$53,234**
Int. EPS	9	15.8	$12,603	$435	**$17,862**	**$24,828**	**$41,240**	**$30,465**	**$37,431**	**$53,843**
Int. SPF	12	14.5	$14,200	$399	**$16,393**	**$22,785**	**$37,846**	**$30,592**	**$36,985**	**$52,046**
ICFs	22	11.6	$16,454	$319	**$13,114**	**$18,228**	**$30,277**	**$29,568**	**$34,682**	**$46,731**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.5	$11,627	$536	**$22,045**	**$30,642**	**$50,897**	**$33,673**	**$42,269**	**$62,524**
Int. Cell.	12	19.5	$11,652	$536	**$22,045**	**$30,642**	**$50,897**	**$33,698**	**$42,295**	**$62,549**
Int. Batt	20	18.1	$11,741	$498	**$20,463**	**$28,442**	**$47,243**	**$32,204**	**$40,183**	**$58,984**
Int. XPS	10	20.1	$12,258	$553	**$22,724**	**$31,585**	**$52,463**	**$34,982**	**$43,843**	**$64,721**
Int. EPS	9	20.3	$12,038	$558	**$22,950**	**$31,900**	**$52,985**	**$34,988**	**$43,938**	**$65,024**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	39.7	$10,283	$1,092	**$44,882**	**$62,385**	**$103,621**	**$55,165**	**$72,667**	**$113,904**

Table 19. Life cycle cost assessment of small basement in Edmonton – 100% efficiency electricity.

VICTORIA – Small Basement Life Cycle Cost Assessments

Victoria climatic conditions cause the least annual basement space heating energy demand among the five locations studied. As a result, the cost of heating basements is generally the lowest estimated in this study. The range of energy prices is narrower than most locations in Canada, and the construction costs are nearly average. Given these circumstances, Class A basements are less cost effective from a thermal efficiency perspective, compared to the other locations considered in this study. However, given the cost of serviced land in lower British Columbia the inclusion of liveable space within the basement may prove more affordable, especially as evidenced in the raised foundation construction traditionally favoured in this region. Regardless, in all cases and across all fuel types, the Class A-3 basement system is the most cost effective under all future energy cost scenarios, when compared to a lower class of basement employing the same thermal/moisture protection option. Life cycle cost assessments for small basement systems located in Victoria are presented in Tables 20 through 23.

Victoria - Natural Gas 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	8.5	$11,217	$164	**$6,727**	**$9,350**	**$15,530**	**$17,944**	**$20,567**	**$26,747**
Ext Fibre	9.9	9.0	$10,820	$173	**$7,122**	**$9,900**	**$16,444**	**$17,943**	**$20,720**	**$27,264**
Ext EPS	11.25	8.6	$10,653	$166	**$6,806**	**$9,460**	**$15,713**	**$17,459**	**$20,113**	**$26,366**
Ext SPF	12	8.5	$11,927	$164	**$6,727**	**$9,350**	**$15,530**	**$18,654**	**$21,277**	**$27,457**
Int. Fibre	12	$10,188	8.1	$156	**$6,410**	**$8,910**	**$14,799**	**$16,598**	**$19,098**	**$24,987**
Int. Cell.	12	$10,241	8.1	$156	**$6,410**	**$8,910**	**$14,799**	**$16,652**	**$19,151**	**$25,041**
Int. Batt	20	$10,427	6.9	$133	**$5,460**	**$7,590**	**$12,607**	**$15,888**	**$18,017**	**$23,034**
Int. XPS	10	$11,515	8.7	$167	**$6,885**	**$9,570**	**$15,896**	**$18,400**	**$21,085**	**$27,410**
Int. EPS	9	$11,053	8.8	$169	**$6,964**	**$9,680**	**$16,078**	**$18,017**	**$20,733**	**$27,131**
Int. SPF	12	$12,745	8.1	$156	**$6,410**	**$8,910**	**$14,799**	**$19,155**	**$21,654**	**$27,544**
ICFs	22	$14,109	6.5	$125	**$5,144**	**$7,150**	**$11,876**	**$19,253**	**$21,259**	**$25,985**
Class B Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	$8,894	11.0	$212	**$8,705**	**$12,100**	**$20,098**	**$17,599**	**$20,994**	**$28,992**
Int. Cell.	12	$8,919	11.0	$212	**$8,705**	**$12,100**	**$20,098**	**$17,624**	**$21,019**	**$29,017**
Int. Batt	20	$9,008	10.2	$196	**$8,072**	**$11,220**	**$18,636**	**$17,080**	**$20,227**	**$27,644**
Int. XPS	10	$9,525	11.4	$219	**$9,022**	**$12,540**	**$20,829**	**$18,547**	**$22,065**	**$30,354**
Int. EPS	9	$9,305	11.4	$219	**$9,022**	**$12,540**	**$20,829**	**$18,327**	**$21,845**	**$30,134**
Class C Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	$8,096	22.2	$427	**$17,569**	**$24,420**	**$40,561**	**$25,665**	**$32,516**	**$48,657**

Table 20. Life cycle cost assessment of small basement in Victoria – 80% efficiency natural gas.

Victoria - Oil 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	8.5	$11,217	$250	**$10,278**	**$14,286**	**$23,729**	**$21,495**	**$25,503**	**$34,946**
Ext Fibre	9.9	9.0	$10,820	$265	**$10,882**	**$15,126**	**$25,125**	**$21,703**	**$25,947**	**$35,945**
Ext EPS	11.25	8.6	$10,653	$253	**$10,399**	**$14,454**	**$24,008**	**$21,052**	**$25,107**	**$34,661**
Ext SPF	12	8.5	$11,927	$250	**$10,278**	**$14,286**	**$23,729**	**$22,205**	**$26,213**	**$35,656**
Int. Fibre	12	$10,188	8.1	$238	**$9,794**	**$13,614**	**$22,612**	**$19,982**	**$23,802**	**$32,800**
Int. Cell.	12	$10,241	8.1	$238	**$9,794**	**$13,614**	**$22,612**	**$20,036**	**$23,855**	**$32,854**
Int. Batt	20	$10,427	6.9	$203	**$8,343**	**$11,597**	**$19,262**	**$18,770**	**$22,024**	**$29,689**
Int. XPS	10	$11,515	8.7	$256	**$10,520**	**$14,622**	**$24,287**	**$22,035**	**$26,137**	**$35,802**
Int. EPS	9	$11,053	8.8	$259	**$10,641**	**$14,790**	**$24,566**	**$21,694**	**$25,843**	**$35,619**
Int. SPF	12	$12,745	8.1	$238	**$9,794**	**$13,614**	**$22,612**	**$22,539**	**$26,358**	**$35,357**
ICFs	22	$14,109	6.5	$191	**$7,860**	**$10,924**	**$18,146**	**$21,969**	**$25,034**	**$32,255**
Class B Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	$8,894	11.0	$324	**$13,301**	**$18,488**	**$30,708**	**$22,195**	**$27,381**	**$39,602**
Int. Cell.	12	$8,919	11.0	$324	**$13,301**	**$18,488**	**$30,708**	**$22,220**	**$27,407**	**$39,627**
Int. Batt	20	$9,008	10.2	$300	**$12,333**	**$17,143**	**$28,475**	**$21,341**	**$26,151**	**$37,482**
Int. XPS	10	$9,525	11.4	$335	**$13,784**	**$19,160**	**$31,825**	**$23,309**	**$28,685**	**$41,349**
Int. EPS	9	$9,305	11.4	$335	**$13,784**	**$19,160**	**$31,825**	**$23,090**	**$28,465**	**$41,130**
Class C Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	$8,096	22.2	$653	**$26,843**	**$37,311**	**$61,974**	**$34,939**	**$45,407**	**$70,070**

Table 21. Life cycle cost assessment of small basement in Victoria – 80% efficiency oil.

Victoria - Propane 80% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	8.5	$11,217	$302	**$12,431**	**$17,279**	**$28,700**	**$23,649**	**$28,496**	**$39,918**
Ext Fibre	9.9	9.0	$10,820	$320	**$13,163**	**$18,295**	**$30,389**	**$23,983**	**$29,116**	**$41,209**
Ext EPS	11.25	8.6	$10,653	$306	**$12,578**	**$17,482**	**$29,038**	**$23,231**	**$28,135**	**$39,691**
Ext SPF	12	8.5	$11,927	$302	**$12,431**	**$17,279**	**$28,700**	**$24,359**	**$29,206**	**$40,628**
Int. Fibre	12	$10,188	8.1	$288	**$11,846**	**$16,466**	**$27,350**	**$22,034**	**$26,654**	**$37,538**
Int. Cell.	12	$10,241	8.1	$288	**$11,846**	**$16,466**	**$27,350**	**$22,088**	**$26,707**	**$37,591**
Int. Batt	20	$10,427	6.9	$245	**$10,091**	**$14,026**	**$23,298**	**$20,518**	**$24,454**	**$33,725**
Int. XPS	10	$11,515	8.7	$310	**$12,724**	**$17,686**	**$29,376**	**$24,239**	**$29,200**	**$40,891**
Int. EPS	9	$11,053	8.8	$313	**$12,870**	**$17,889**	**$29,713**	**$23,923**	**$28,942**	**$40,766**
Int. SPF	12	$12,745	8.1	$288	**$11,846**	**$16,466**	**$27,350**	**$24,591**	**$29,210**	**$40,094**
ICFs	22	$14,109	6.5	$231	**$9,506**	**$13,213**	**$21,947**	**$23,616**	**$27,323**	**$36,057**
Class B Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	$8,894	11.0	$391	**$16,088**	**$22,361**	**$37,142**	**$24,981**	**$31,255**	**$46,036**
Int. Cell.	12	$8,919	11.0	$391	**$16,088**	**$22,361**	**$37,142**	**$25,007**	**$31,280**	**$46,061**
Int. Batt	20	$9,008	10.2	$363	**$14,918**	**$20,735**	**$34,441**	**$23,925**	**$29,742**	**$43,448**
Int. XPS	10	$9,525	11.4	$406	**$16,673**	**$23,174**	**$38,492**	**$26,197**	**$32,699**	**$48,017**
Int. EPS	9	$9,305	11.4	$406	**$16,673**	**$23,174**	**$38,492**	**$25,978**	**$32,479**	**$47,798**
Class C Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	$8,096	22.2	$790	**$32,468**	**$45,129**	**$74,959**	**$40,564**	**$53,225**	**$83,055**

Table 22. Life cycle cost assessment of small basement in Victoria – 80% efficiency propane.

Victoria - Electricity 100% Efficiency, Small Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	8.5	$11,217	$165	**$6,765**	**$9,403**	**$15,619**	**$17,982**	**$20,621**	**$26,836**
Ext Fibre	9.9	9.0	$10,820	$174	**$7,163**	**$9,956**	**$16,538**	**$17,984**	**$20,777**	**$27,358**
Ext EPS	11.25	8.6	$10,653	$166	**$6,845**	**$9,514**	**$15,803**	**$17,498**	**$20,167**	**$26,456**
Ext SPF	12	8.5	$11,927	$165	**$6,765**	**$9,403**	**$15,619**	**$18,692**	**$21,331**	**$27,546**
Int. Fibre	12	$10,188	8.1	$157	**$6,447**	**$8,961**	**$14,884**	**$16,635**	**$19,149**	**$25,072**
Int. Cell.	12	$10,241	8.1	$157	**$6,447**	**$8,961**	**$14,884**	**$16,688**	**$19,202**	**$25,125**
Int. Batt	20	$10,427	6.9	$134	**$5,492**	**$7,633**	**$12,679**	**$15,919**	**$18,060**	**$23,106**
Int. XPS	10	$11,515	8.7	$168	**$6,924**	**$9,625**	**$15,986**	**$18,439**	**$21,139**	**$27,501**
Int. EPS	9	$11,053	8.8	$170	**$7,004**	**$9,735**	**$16,170**	**$18,057**	**$20,788**	**$27,223**
Int. SPF	12	$12,745	8.1	$157	**$6,447**	**$8,961**	**$14,884**	**$19,191**	**$21,705**	**$27,628**
ICFs	22	$14,109	6.5	$126	**$5,173**	**$7,191**	**$11,944**	**$19,283**	**$21,300**	**$26,053**
Class B Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	$8,894	11.0	$213	**$8,755**	**$12,169**	**$20,213**	**$17,649**	**$21,063**	**$29,106**
Int. Cell.	12	$8,919	11.0	$213	**$8,755**	**$12,169**	**$20,213**	**$17,674**	**$21,088**	**$29,132**
Int. Batt	20	$9,008	10.2	$197	**$8,118**	**$11,284**	**$18,743**	**$17,126**	**$20,291**	**$27,750**
Int. XPS	10	$9,525	11.4	$221	**$9,073**	**$12,611**	**$20,948**	**$18,598**	**$22,136**	**$30,473**
Int. EPS	9	$9,305	11.4	$221	**$9,073**	**$12,611**	**$20,948**	**$18,378**	**$21,917**	**$30,253**
Class C Basement										
Basement		**Capital**	**Annual**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**Cost**	**GJ**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	$8,096	22.2	$430	**$17,669**	**$24,559**	**$40,793**	**$25,765**	**$32,655**	**$48,889**

Table 23. Life cycle cost assessment of small basement in Victoria – 100% efficiency electricity.

TORONTO – Large Basement Life Cycle Cost Assessments

Life cycle cost assessments of the large basement model exhibit similar relationships to the small model in all of the five locations considered by this study. A notable difference is in the capital cost and the annual operating energy, which are considerably higher. However, on a unit floor area basis, large basements cost less to construct and operate than small basements with similar geometries. Despite these differences, the rankings for life cycle cost effectiveness are virtually identical for large basements and small basements. It may be concluded that for model energy code development purposes, a single, small basement model provides meaningful cost-benefit analyses.

Life cycle cost assessments for large basement systems located in Toronto are presented in Tables 24 through 27.

Toronto - Natural Gas 80% Efficiency, Large Basement

Basement		Annual	Capital	Annual	LCC of Energy			LCC of Basement System		
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	17.6	$23,874	$330	**$13,575**	**$18,869**	**$31,342**	**$37,450**	**$42,744**	**$55,216**
Ext Fibre	9.9	18.8	$23,200	$353	**$14,501**	**$20,156**	**$33,479**	**$37,701**	**$43,356**	**$56,679**
Ext EPS	11.25	17.9	$22,916	$336	**$13,807**	**$19,191**	**$31,876**	**$36,723**	**$42,107**	**$54,792**
Ext SPF	12	17.6	$25,080	$330	**$13,575**	**$18,869**	**$31,342**	**$38,656**	**$43,950**	**$56,422**
Int. Fibre	12	17.2	$20,928	$323	**$13,267**	**$18,441**	**$30,630**	**$34,195**	**$39,368**	**$51,558**
Int. Cell.	12	17.2	$21,019	$323	**$13,267**	**$18,441**	**$30,630**	**$34,285**	**$39,459**	**$51,648**
Int. Batt	20	14.3	$21,334	$268	**$11,030**	**$15,331**	**$25,465**	**$32,364**	**$36,665**	**$46,799**
Int. XPS	10	18.4	$23,182	$345	**$14,193**	**$19,727**	**$32,767**	**$37,374**	**$42,909**	**$55,948**
Int. EPS	9	18.9	$22,397	$355	**$14,578**	**$20,263**	**$33,657**	**$36,975**	**$42,660**	**$56,054**
Int. SPF	12	17.2	$25,271	$323	**$13,267**	**$18,441**	**$30,630**	**$38,537**	**$43,711**	**$55,900**
ICFs	22	13.0	$29,941	$244	**$10,027**	**$13,938**	**$23,150**	**$39,968**	**$43,878**	**$53,091**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	23.5	$16,803	$441	**$18,126**	**$25,195**	**$41,849**	**$34,929**	**$41,998**	**$58,651**
Int. Cell.	12	23.5	$16,842	$441	**$18,126**	**$25,195**	**$41,849**	**$34,968**	**$42,037**	**$58,691**
Int. Batt	20	21.7	$16,978	$407	**$16,738**	**$23,265**	**$38,643**	**$33,715**	**$40,243**	**$55,621**
Int. XPS	10	24.3	$17,773	$456	**$18,743**	**$26,053**	**$43,273**	**$36,517**	**$43,826**	**$61,047**
Int. EPS	9	24.7	$17,435	$463	**$19,052**	**$26,482**	**$43,986**	**$36,487**	**$43,917**	**$61,421**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	53.7	$15,575	$1,008	**$41,421**	**$57,573**	**$95,629**	**$56,996**	**$73,148**	**$111,204**

Table 24. Life cycle cost assessment of large basement in Toronto – 80% efficiency natural gas.

Toronto - Oil 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	17.6	$23,874	$475	**$19,509**	**$27,116**	**$45,040**	**$43,383**	**$50,990**	**$68,914**
Ext Fibre	9.9	18.8	$23,200	$507	**$20,839**	**$28,965**	**$48,111**	**$44,039**	**$52,165**	**$71,311**
Ext EPS	11.25	17.9	$22,916	$483	**$19,841**	**$27,578**	**$45,808**	**$42,757**	**$50,494**	**$68,723**
Ext SPF	12	17.6	$25,080	$475	**$19,509**	**$27,116**	**$45,040**	**$44,589**	**$52,196**	**$70,120**
Int. Fibre	12	17.2	$20,928	$464	**$19,065**	**$26,500**	**$44,016**	**$39,993**	**$47,428**	**$64,944**
Int. Cell.	12	17.2	$21,019	$464	**$19,065**	**$26,500**	**$44,016**	**$40,084**	**$47,518**	**$65,035**
Int. Batt	20	14.3	$21,334	$386	**$15,851**	**$22,032**	**$36,595**	**$37,185**	**$43,366**	**$57,929**
Int. XPS	10	18.4	$23,182	$496	**$20,395**	**$28,349**	**$47,087**	**$43,577**	**$51,530**	**$70,269**
Int. EPS	9	18.9	$22,397	$510	**$20,950**	**$29,119**	**$48,367**	**$43,347**	**$51,516**	**$70,764**
Int. SPF	12	17.2	$25,271	$464	**$19,065**	**$26,500**	**$44,016**	**$44,336**	**$51,770**	**$69,287**
ICFs	22	13.0	$29,941	$351	**$14,410**	**$20,029**	**$33,268**	**$44,350**	**$49,970**	**$63,209**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	23.5	$16,803	$634	**$26,048**	**$36,206**	**$60,139**	**$42,851**	**$53,009**	**$76,941**
Int. Cell.	12	23.5	$16,842	$634	**$26,048**	**$36,206**	**$60,139**	**$42,890**	**$53,048**	**$76,980**
Int. Batt	20	21.7	$16,978	$585	**$24,053**	**$33,433**	**$55,532**	**$41,031**	**$50,410**	**$72,510**
Int. XPS	10	24.3	$17,773	$655	**$26,935**	**$37,439**	**$62,186**	**$44,709**	**$55,212**	**$79,959**
Int. EPS	9	24.7	$17,435	$666	**$27,378**	**$38,055**	**$63,209**	**$44,814**	**$55,491**	**$80,645**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	53.7	$15,575	$1,448	**$59,523**	**$82,735**	**$137,423**	**$75,099**	**$98,310**	**$152,998**

Table 25. Life cycle cost assessment of large basement in Toronto – 80% efficiency oil.

Toronto - Propane 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	17.6	$23,874	$644	**$26,455**	**$36,771**	**$61,076**	**$50,329**	**$60,645**	**$84,950**
Ext Fibre	9.9	18.8	$23,200	$687	**$28,258**	**$39,278**	**$65,241**	**$51,458**	**$62,478**	**$88,441**
Ext EPS	11.25	17.9	$22,916	$654	**$26,905**	**$37,398**	**$62,117**	**$49,821**	**$60,313**	**$85,033**
Ext SPF	12	17.6	$25,080	$644	**$26,455**	**$36,771**	**$61,076**	**$51,535**	**$61,851**	**$86,157**
Int. Fibre	12	17.2	$20,928	$629	**$25,853**	**$35,935**	**$59,688**	**$46,781**	**$56,863**	**$80,616**
Int. Cell.	12	17.2	$21,019	$629	**$25,853**	**$35,935**	**$59,688**	**$46,872**	**$56,954**	**$80,707**
Int. Batt	20	14.3	$21,334	$523	**$21,494**	**$29,876**	**$49,625**	**$42,828**	**$51,210**	**$70,958**
Int. XPS	10	18.4	$23,182	$673	**$27,657**	**$38,442**	**$63,853**	**$50,839**	**$61,624**	**$87,034**
Int. EPS	9	18.9	$22,397	$691	**$28,409**	**$39,487**	**$65,588**	**$50,806**	**$61,884**	**$87,985**
Int. SPF	12	17.2	$25,271	$629	**$25,853**	**$35,935**	**$59,688**	**$51,124**	**$61,206**	**$84,959**
ICFs	22	13.0	$29,941	$475	**$19,540**	**$27,160**	**$45,113**	**$49,481**	**$57,101**	**$75,054**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	23.5	$16,803	$859	**$35,323**	**$49,097**	**$81,551**	**$52,125**	**$65,900**	**$98,353**
Int. Cell.	12	23.5	$16,842	$859	**$35,323**	**$49,097**	**$81,551**	**$52,165**	**$65,939**	**$98,393**
Int. Batt	20	21.7	$16,978	$793	**$32,617**	**$45,337**	**$75,304**	**$49,595**	**$62,314**	**$92,282**
Int. XPS	10	24.3	$17,773	$888	**$36,525**	**$50,769**	**$84,327**	**$54,299**	**$68,542**	**$102,101**
Int. EPS	9	24.7	$17,435	$903	**$37,127**	**$51,605**	**$85,715**	**$54,562**	**$69,040**	**$103,151**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	53.7	$15,575	$1,963	**$80,716**	**$112,193**	**$186,352**	**$96,292**	**$127,768**	**$201,928**

Table 26. Life cycle cost assessment of large basement in Toronto – 80% efficiency propane.

Toronto - Electricity 100% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	17.6	$23,874	$469	**$19,297**	**$26,822**	**$44,551**	**$43,171**	**$50,696**	**$68,425**
Ext Fibre	9.9	18.8	$23,200	$501	**$20,613**	**$28,651**	**$47,589**	**$43,813**	**$51,851**	**$70,789**
Ext EPS	11.25	17.9	$22,916	$477	**$19,626**	**$27,279**	**$45,311**	**$42,542**	**$50,195**	**$68,226**
Ext SPF	12	17.6	$25,080	$469	**$19,297**	**$26,822**	**$44,551**	**$44,377**	**$51,902**	**$69,631**
Int. Fibre	12	17.2	$20,928	$459	**$18,858**	**$26,212**	**$43,539**	**$39,786**	**$47,140**	**$64,467**
Int. Cell.	12	17.2	$21,019	$459	**$18,858**	**$26,212**	**$43,539**	**$39,877**	**$47,231**	**$64,557**
Int. Batt	20	14.3	$21,334	$381	**$15,679**	**$21,793**	**$36,198**	**$37,013**	**$43,127**	**$57,532**
Int. XPS	10	18.4	$23,182	$491	**$20,174**	**$28,041**	**$46,576**	**$43,356**	**$51,223**	**$69,758**
Int. EPS	9	18.9	$22,397	$504	**$20,722**	**$28,803**	**$47,842**	**$43,119**	**$51,200**	**$70,239**
Int. SPF	12	17.2	$25,271	$459	**$18,858**	**$26,212**	**$43,539**	**$44,129**	**$51,483**	**$68,809**
ICFs	22	13.0	$29,941	$347	**$14,253**	**$19,812**	**$32,907**	**$44,194**	**$49,752**	**$62,848**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	23.5	$16,803	$627	**$25,766**	**$35,813**	**$59,486**	**$42,568**	**$52,616**	**$76,289**
Int. Cell.	12	23.5	$16,842	$627	**$25,766**	**$35,813**	**$59,486**	**$42,607**	**$52,655**	**$76,328**
Int. Batt	20	21.7	$16,978	$579	**$23,792**	**$33,070**	**$54,930**	**$40,770**	**$50,048**	**$71,907**
Int. XPS	10	24.3	$17,773	$648	**$26,643**	**$37,033**	**$61,511**	**$44,416**	**$54,806**	**$79,285**
Int. EPS	9	24.7	$17,435	$659	**$27,081**	**$37,642**	**$62,524**	**$44,517**	**$55,078**	**$79,959**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	53.7	$15,575	$1,432	**$58,878**	**$81,838**	**$135,932**	**$74,453**	**$97,413**	**$151,507**

Table 27. Life cycle cost assessment of large basement in Toronto – 100% efficiency electricity.

OTTAWA – Large Basement Life Cycle Cost Assessments

Life cycle cost assessments for large basement systems located in Ottawa are presented in Tables 28 through 31.

Ottawa - Natural Gas 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	20.8	$25,106	$390	**$16,044**	**$22,300**	**$37,041**	**$41,150**	**$47,406**	**$62,147**
Ext Fibre	9.9	22.3	$24,473	$418	**$17,201**	**$23,908**	**$39,712**	**$41,673**	**$48,381**	**$64,185**
Ext EPS	11.25	21.3	$24,206	$400	**$16,429**	**$22,836**	**$37,931**	**$40,635**	**$47,042**	**$62,137**
Ext SPF	12	20.8	$26,239	$390	**$16,044**	**$22,300**	**$37,041**	**$42,283**	**$48,539**	**$63,280**
Int. Fibre	12	20.4	$22,338	$383	**$15,735**	**$21,871**	**$36,328**	**$38,073**	**$44,209**	**$58,666**
Int. Cell.	12	20.4	$22,423	$383	**$15,735**	**$21,871**	**$36,328**	**$38,158**	**$44,295**	**$58,752**
Int. Batt	20	17.1	$22,720	$321	**$13,190**	**$18,333**	**$30,452**	**$35,909**	**$41,053**	**$53,171**
Int. XPS	10	21.8	$24,456	$409	**$16,815**	**$23,372**	**$38,821**	**$41,271**	**$47,828**	**$63,277**
Int. EPS	9	22.4	$23,718	$420	**$17,278**	**$24,016**	**$39,890**	**$40,996**	**$47,734**	**$63,608**
Int. SPF	12	20.4	$26,418	$383	**$15,735**	**$21,871**	**$36,328**	**$42,153**	**$48,289**	**$62,746**
ICFs	22	15.6	$31,929	$293	**$12,033**	**$16,725**	**$27,781**	**$43,962**	**$48,655**	**$59,710**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	28.8	$19,256	$540	**$22,214**	**$30,877**	**$51,287**	**$41,471**	**$50,134**	**$70,543**
Int. Cell.	12	27.8	$19,295	$522	**$21,443**	**$29,805**	**$49,506**	**$40,739**	**$49,101**	**$68,802**
Int. Batt	20	25.7	$19,431	$482	**$19,823**	**$27,554**	**$45,767**	**$39,255**	**$46,985**	**$65,198**
Int. XPS	10	28.8	$20,227	$540	**$22,214**	**$30,877**	**$51,287**	**$42,442**	**$51,105**	**$71,514**
Int. EPS	9	29.1	$19,889	$546	**$22,446**	**$31,199**	**$51,821**	**$42,335**	**$51,088**	**$71,711**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	62.1	$18,029	$1,165	**$47,900**	**$66,579**	**$110,588**	**$65,929**	**$84,608**	**$128,617**

Table 28. Life cycle cost assessment of large basement in Ottawa – 80% efficiency natural gas.

Ottawa - Oil 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	20.8	$25,106	$574	**$23,611**	**$32,819**	**$54,512**	**$48,717**	**$57,925**	**$79,618**
Ext Fibre	9.9	22.3	$24,473	$616	**$25,314**	**$35,186**	**$58,443**	**$49,787**	**$59,658**	**$82,916**
Ext EPS	11.25	21.3	$24,206	$588	**$24,179**	**$33,608**	**$55,823**	**$48,385**	**$57,814**	**$80,028**
Ext SPF	12	20.8	$26,239	$574	**$23,611**	**$32,819**	**$54,512**	**$49,851**	**$59,058**	**$80,751**
Int. Fibre	12	20.4	$22,338	$563	**$23,157**	**$32,188**	**$53,464**	**$45,495**	**$54,526**	**$75,802**
Int. Cell.	12	20.4	$22,423	$563	**$23,157**	**$32,188**	**$53,464**	**$45,581**	**$54,611**	**$75,887**
Int. Batt	20	17.1	$22,720	$472	**$19,411**	**$26,981**	**$44,815**	**$42,131**	**$49,700**	**$67,535**
Int. XPS	10	21.8	$24,456	$602	**$24,747**	**$34,397**	**$57,133**	**$49,202**	**$58,852**	**$81,589**
Int. EPS	9	22.4	$23,718	$619	**$25,428**	**$35,343**	**$58,705**	**$49,146**	**$59,062**	**$82,424**
Int. SPF	12	20.4	$26,418	$563	**$23,157**	**$32,188**	**$53,464**	**$49,575**	**$58,606**	**$79,882**
ICFs	22	15.6	$31,929	$431	**$17,709**	**$24,614**	**$40,884**	**$49,638**	**$56,544**	**$72,814**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	28.8	$19,256	$795	**$32,693**	**$45,442**	**$75,478**	**$51,949**	**$64,698**	**$94,735**
Int. Cell.	12	27.8	$19,295	$768	**$31,558**	**$43,864**	**$72,858**	**$50,853**	**$63,159**	**$92,153**
Int. Batt	20	25.7	$19,431	$710	**$29,174**	**$40,550**	**$67,354**	**$48,605**	**$59,982**	**$86,785**
Int. XPS	10	28.8	$20,227	$795	**$32,693**	**$45,442**	**$75,478**	**$52,920**	**$65,669**	**$95,706**
Int. EPS	9	29.1	$19,889	$804	**$33,033**	**$45,915**	**$76,265**	**$52,922**	**$65,804**	**$96,154**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	62.1	$18,029	$1,715	**$70,494**	**$97,983**	**$162,750**	**$88,523**	**$116,012**	**$180,780**

Table 29. Life cycle cost assessment of large basement in Ottawa – 80% efficiency oil.

Ottawa - Propane 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	20.8	$25,106	$750	**$30,837**	**$42,862**	**$71,194**	**$55,943**	**$67,968**	**$96,300**
Ext Fibre	9.9	22.3	$24,473	$804	**$33,061**	**$45,953**	**$76,328**	**$57,533**	**$70,426**	**$100,801**
Ext EPS	11.25	21.3	$24,206	$768	**$31,578**	**$43,893**	**$72,905**	**$55,784**	**$68,098**	**$97,111**
Ext SPF	12	20.8	$26,239	$750	**$30,837**	**$42,862**	**$71,194**	**$57,076**	**$69,101**	**$97,433**
Int. Fibre	12	20.4	$22,338	$736	**$30,244**	**$42,038**	**$69,825**	**$52,582**	**$64,376**	**$92,163**
Int. Cell.	12	20.4	$22,423	$736	**$30,244**	**$42,038**	**$69,825**	**$52,667**	**$64,461**	**$92,248**
Int. Batt	20	17.1	$22,720	$617	**$25,352**	**$35,238**	**$58,530**	**$48,071**	**$57,957**	**$81,249**
Int. XPS	10	21.8	$24,456	$786	**$32,319**	**$44,923**	**$74,617**	**$56,775**	**$69,378**	**$99,072**
Int. EPS	9	22.4	$23,718	$808	**$33,209**	**$46,159**	**$76,671**	**$56,927**	**$69,878**	**$100,389**
Int. SPF	12	20.4	$26,418	$736	**$30,244**	**$42,038**	**$69,825**	**$56,662**	**$68,456**	**$96,243**
ICFs	22	15.6	$31,929	$563	**$23,128**	**$32,147**	**$53,396**	**$55,057**	**$64,076**	**$85,325**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	28.8	$19,256	$1,039	**$42,697**	**$59,348**	**$98,576**	**$61,954**	**$78,604**	**$117,833**
Int. Cell.	12	27.8	$19,295	$1,003	**$41,215**	**$57,287**	**$95,154**	**$60,510**	**$76,582**	**$114,449**
Int. Batt	20	25.7	$19,431	$927	**$38,101**	**$52,960**	**$87,966**	**$57,533**	**$72,391**	**$107,397**
Int. XPS	10	28.8	$20,227	$1,039	**$42,697**	**$59,348**	**$98,576**	**$62,925**	**$79,575**	**$118,804**
Int. EPS	9	29.1	$19,889	$1,049	**$43,142**	**$59,966**	**$99,603**	**$63,031**	**$79,855**	**$119,493**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	62.1	$18,029	$2,239	**$92,066**	**$127,968**	**$212,555**	**$110,095**	**$145,997**	**$230,585**

Table 30. Life cycle cost assessment of large basement in Ottawa – 80% efficiency propane.

Ottawa - Electricity 100% Efficiency, Large Basement											
Class A-3 Basement (Full Height Insulation, Unfinished)											
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**			
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***	
Ext XPS	12	20.8	$25,106	$555	**$22,805**	**$31,699**	**$52,652**	**$47,912**	**$56,805**	**$77,758**	
Ext Fibre	9.9	22.3	$24,473	$595	**$24,450**	**$33,985**	**$56,449**	**$48,923**	**$58,457**	**$80,921**	
Ext EPS	11.25	21.3	$24,206	$568	**$23,354**	**$32,461**	**$53,917**	**$47,559**	**$56,666**	**$78,123**	
Ext SPF	12	20.8	$26,239	$555	**$22,805**	**$31,699**	**$52,652**	**$49,045**	**$57,938**	**$78,891**	
Int. Fibre	12	20.4	$22,338	$544	**$22,367**	**$31,089**	**$51,639**	**$44,705**	**$53,427**	**$73,977**	
Int. Cell.	12	20.4	$22,423	$544	**$22,367**	**$31,089**	**$51,639**	**$44,790**	**$53,512**	**$74,062**	
Int. Batt	20	17.1	$22,720	$456	**$18,749**	**$26,060**	**$43,286**	**$41,468**	**$48,780**	**$66,005**	
Int. XPS	10	21.8	$24,456	$581	**$23,902**	**$33,223**	**$55,183**	**$48,357**	**$57,678**	**$79,638**	
Int. EPS	9	22.4	$23,718	$597	**$24,560**	**$34,137**	**$56,702**	**$48,278**	**$57,855**	**$80,420**	
Int. SPF	12	20.4	$26,418	$544	**$22,367**	**$31,089**	**$51,639**	**$48,785**	**$57,507**	**$78,057**	
ICFs	22	15.6	$31,929	$416	**$17,104**	**$23,774**	**$39,489**	**$49,033**	**$55,703**	**$71,418**	
Class B Basement											
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**			
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***	
Int. Fibre	12	28.8	$19,256	$768	**$31,577**	**$43,891**	**$72,902**	**$50,833**	**$63,147**	**$92,159**	
Int. Cell.	12	27.8	$19,295	$741	**$30,480**	**$42,367**	**$70,371**	**$49,776**	**$61,662**	**$89,666**	
Int. Batt	20	25.7	$19,431	$685	**$28,178**	**$39,166**	**$65,055**	**$47,609**	**$58,597**	**$84,486**	
Int. XPS	10	28.8	$20,227	$768	**$31,577**	**$43,891**	**$72,902**	**$51,804**	**$64,118**	**$93,129**	
Int. EPS	9	29.1	$19,889	$776	**$31,906**	**$44,348**	**$73,662**	**$51,795**	**$64,237**	**$93,551**	
Class C Basement											
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**			
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***	
Elec. 100%	N/A	62.1	$18,029	$1,656	**$68,087**	**$94,639**	**$157,195**	**$86,116**	**$112,668**	**$175,224**	

Table 31. Life cycle cost assessment of large basement in Ottawa – 100% efficiency electricity.

HALIFAX – Large Basement Life Cycle Cost Assessments

Life cycle cost assessments for large basement systems located in Halifax are presented in Tables 32 through 34. It is interesting to note that coincidentally, the annual energy demand for the *Ext. Fibre* and the *Int. EPS* basement insulation options are equal for the large basement model, resulting in identical life cycle energy costs.

Halifax - Oil 80% Efficiency, Large Basement

Basement Option	R-Value	Annual GJ	Capital Cost	Annual Energy	LCC of Energy Low	LCC of Energy Current	LCC of Energy High	LCC of Basement System Low	LCC of Basement System Current	LCC of Basement System High
Class A-3 Basement (Full Height Insulation, Unfinished)										
Ext XPS	12	20.1	$19,193	$581	**$23,901**	**$33,222**	**$55,182**	**$43,094**	**$52,415**	**$74,375**
Ext Fibre	9.9	21.4	$18,634	$619	**$25,447**	**$35,371**	**$58,751**	**$44,081**	**$54,005**	**$77,385**
Ext EPS	11.25	20.6	$18,398	$596	**$24,496**	**$34,048**	**$56,554**	**$42,894**	**$52,447**	**$74,953**
Ext SPF	12	20.1	$20,194	$581	**$23,901**	**$33,222**	**$55,182**	**$44,095**	**$53,416**	**$75,375**
Int. Fibre	12	19.7	$16,749	$570	**$23,426**	**$32,561**	**$54,083**	**$40,175**	**$49,310**	**$70,833**
Int. Cell.	12	19.7	$16,825	$570	**$23,426**	**$32,561**	**$54,083**	**$40,250**	**$49,385**	**$70,908**
Int. Batt	20	16.5	$17,086	$477	**$19,620**	**$27,272**	**$45,298**	**$36,707**	**$44,358**	**$62,384**
Int. XPS	10	21.0	$18,619	$607	**$24,972**	**$34,709**	**$57,652**	**$43,590**	**$53,328**	**$76,271**
Int. EPS	9	21.4	$17,968	$619	**$25,447**	**$35,371**	**$58,751**	**$43,415**	**$53,339**	**$76,719**
Int. SPF	12	19.7	$20,352	$570	**$23,426**	**$32,561**	**$54,083**	**$43,777**	**$52,912**	**$74,435**
ICFs	22	15.2	$23,969	$440	**$18,075**	**$25,123**	**$41,729**	**$42,044**	**$49,092**	**$65,698**
Class B Basement										
Int. Fibre	12	26.7	$16,169	$772	**$31,749**	**$44,131**	**$73,301**	**$47,918**	**$60,300**	**$89,470**
Int. Cell.	12	26.7	$16,208	$772	**$31,749**	**$44,131**	**$73,301**	**$47,958**	**$60,339**	**$89,509**
Int. Batt	20	24.7	$16,344	$714	**$29,371**	**$40,825**	**$67,810**	**$45,715**	**$57,169**	**$84,154**
Int. XPS	10	27.6	$17,140	$798	**$32,820**	**$45,618**	**$75,772**	**$49,960**	**$62,758**	**$92,912**
Int. EPS	9	27.9	$16,802	$807	**$33,176**	**$46,114**	**$76,595**	**$49,978**	**$62,916**	**$93,397**
Class C Basement										
Oil 80%	N/A	58.2	$14,942	$1,683	**$69,207**	**$96,195**	**$159,780**	**$84,148**	**$111,136**	**$174,721**

Table 32. Life cycle cost assessment of large basement in Halifax – 80% efficiency oil.

Halifax - Propane 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	20.1	$19,193	$1,023	**$42,049**	**$58,447**	**$97,080**	**$61,243**	**$77,640**	**$116,274**
Ext Fibre	9.9	21.4	$18,634	$1,089	**$44,769**	**$62,227**	**$103,359**	**$63,403**	**$80,861**	**$121,993**
Ext EPS	11.25	20.6	$18,398	$1,048	**$43,095**	**$59,901**	**$99,495**	**$61,494**	**$78,299**	**$117,894**
Ext SPF	12	20.1	$20,194	$1,023	**$42,049**	**$58,447**	**$97,080**	**$62,243**	**$78,641**	**$117,274**
Int. Fibre	12	19.7	$16,749	$1,002	**$41,213**	**$57,284**	**$95,149**	**$57,962**	**$74,033**	**$111,898**
Int. Cell.	12	19.7	$16,825	$1,002	**$41,213**	**$57,284**	**$95,149**	**$58,037**	**$74,108**	**$111,973**
Int. Batt	20	16.5	$17,086	$840	**$34,518**	**$47,979**	**$79,693**	**$51,604**	**$65,065**	**$96,779**
Int. XPS	10	21.0	$18,619	$1,069	**$43,932**	**$61,064**	**$101,427**	**$62,551**	**$79,683**	**$120,046**
Int. EPS	9	21.4	$17,968	$1,089	**$44,769**	**$62,227**	**$103,359**	**$62,737**	**$80,195**	**$121,327**
Int. SPF	12	19.7	$20,352	$1,002	**$41,213**	**$57,284**	**$95,149**	**$61,564**	**$77,635**	**$115,500**
ICFs	22	15.2	$23,969	$773	**$31,799**	**$44,199**	**$73,414**	**$55,768**	**$68,168**	**$97,383**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	26.7	$16,169	$1,359	**$55,857**	**$77,639**	**$128,958**	**$72,026**	**$93,808**	**$145,127**
Int. Cell.	12	26.7	$16,208	$1,359	**$55,857**	**$77,639**	**$128,958**	**$72,065**	**$93,847**	**$145,166**
Int. Batt	20	24.7	$16,344	$1,257	**$51,673**	**$71,823**	**$119,298**	**$68,016**	**$88,167**	**$135,642**
Int. XPS	10	27.6	$17,140	$1,404	**$57,739**	**$80,256**	**$133,305**	**$74,879**	**$97,395**	**$150,444**
Int. EPS	9	27.9	$16,802	$1,420	**$58,367**	**$81,128**	**$134,754**	**$75,169**	**$97,930**	**$151,555**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	58.2	$14,942	$2,962	**$121,755**	**$169,235**	**$281,099**	**$136,697**	**$184,176**	**$296,040**

Table 33. Life cycle cost assessment of large basement in Halifax – 80% efficiency propane.

Halifax - Electricity 100% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	20.1	$19,193	$592	**$24,327**	**$33,813**	**$56,164**	**$43,520**	**$53,007**	**$75,357**
Ext Fibre	9.9	21.4	$18,634	$630	**$25,900**	**$36,000**	**$59,797**	**$44,534**	**$54,634**	**$78,431**
Ext EPS	11.25	20.6	$18,398	$606	**$24,932**	**$34,655**	**$57,561**	**$43,330**	**$53,053**	**$75,959**
Ext SPF	12	20.1	$20,194	$592	**$24,327**	**$33,813**	**$56,164**	**$44,520**	**$54,007**	**$76,358**
Int. Fibre	12	19.7	$16,749	$580	**$23,843**	**$33,141**	**$55,046**	**$40,592**	**$49,890**	**$71,796**
Int. Cell.	12	19.7	$16,825	$580	**$23,843**	**$33,141**	**$55,046**	**$40,667**	**$49,965**	**$71,871**
Int. Batt	20	16.5	$17,086	$486	**$19,970**	**$27,757**	**$46,105**	**$37,056**	**$44,843**	**$63,191**
Int. XPS	10	21.0	$18,619	$618	**$25,416**	**$35,327**	**$58,679**	**$44,035**	**$53,946**	**$77,298**
Int. EPS	9	21.4	$17,968	$630	**$25,900**	**$36,000**	**$59,797**	**$43,868**	**$53,968**	**$77,765**
Int. SPF	12	19.7	$20,352	$580	**$23,843**	**$33,141**	**$55,046**	**$44,194**	**$53,492**	**$75,398**
ICFs	22	15.2	$23,969	$447	**$18,396**	**$25,570**	**$42,472**	**$42,365**	**$49,539**	**$66,441**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	26.7	$16,169	$786	**$32,315**	**$44,916**	**$74,606**	**$48,484**	**$61,085**	**$90,775**
Int. Cell.	12	26.7	$16,208	$786	**$32,315**	**$44,916**	**$74,606**	**$48,523**	**$61,124**	**$90,814**
Int. Batt	20	24.7	$16,344	$727	**$29,894**	**$41,552**	**$69,018**	**$46,238**	**$57,896**	**$85,361**
Int. XPS	10	27.6	$17,140	$813	**$33,404**	**$46,430**	**$77,121**	**$50,544**	**$63,570**	**$94,261**
Int. EPS	9	27.9	$16,802	$821	**$33,767**	**$46,935**	**$77,959**	**$50,569**	**$63,737**	**$94,761**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	58.2	$14,942	$1,713	**$70,439**	**$97,908**	**$162,624**	**$85,381**	**$112,849**	**$177,566**

Table 34. Life cycle cost assessment of large basement in Halifax – 100% efficiency electricty.

EDMONTON – Large Basement Life Cycle Cost Assessments

Life cycle cost assessments for large basement systems located in Edmonton are presented in Tables 35 through 38. Again, the annual energy demand for the *Ext. Fibre* and the *Int. EPS* basement insulation options are coincidentally equal for the large basement model, resulting in identical life cycle energy costs.

Edmonton - Natural Gas 80% Efficiency, Large Basement

Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	25.8	$21,941	$233	**$9,559**	**$13,287**	**$22,069**	**$31,500**	**$35,228**	**$44,011**
Ext Fibre	9.9	27.5	$21,365	$248	**$10,189**	**$14,162**	**$23,524**	**$31,554**	**$35,527**	**$44,888**
Ext EPS	11.25	26.4	$21,122	$238	**$9,781**	**$13,596**	**$22,583**	**$30,903**	**$34,718**	**$43,705**
Ext SPF	12	25.8	$22,972	$233	**$9,559**	**$13,287**	**$22,069**	**$32,531**	**$36,259**	**$45,042**
Int. Fibre	12	25.3	$19,423	$228	**$9,374**	**$13,029**	**$21,642**	**$28,796**	**$32,452**	**$41,064**
Int. Cell.	12	25.3	$19,500	$228	**$9,374**	**$13,029**	**$21,642**	**$28,874**	**$32,529**	**$41,142**
Int. Batt	20	21.3	$19,770	$192	**$7,892**	**$10,969**	**$18,220**	**$27,661**	**$30,739**	**$37,990**
Int. XPS	10	26.9	$21,349	$242	**$9,967**	**$13,853**	**$23,010**	**$31,316**	**$35,203**	**$44,360**
Int. EPS	9	27.5	$20,679	$248	**$10,189**	**$14,162**	**$23,524**	**$30,867**	**$34,841**	**$44,202**
Int. SPF	12	25.3	$23,135	$228	**$9,374**	**$13,029**	**$21,642**	**$32,509**	**$36,164**	**$44,777**
ICFs	22	19.3	$27,771	$174	**$7,151**	**$9,939**	**$16,509**	**$34,921**	**$37,710**	**$44,280**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	33.9	$18,346	$306	**$12,560**	**$17,458**	**$28,998**	**$30,907**	**$35,805**	**$47,344**
Int. Cell.	12	33.9	$18,385	$306	**$12,560**	**$17,458**	**$28,998**	**$30,946**	**$35,844**	**$47,383**
Int. Batt	20	31.4	$18,521	$283	**$11,634**	**$16,171**	**$26,860**	**$30,155**	**$34,692**	**$45,381**
Int. XPS	10	35.1	$19,317	$316	**$13,005**	**$18,076**	**$30,025**	**$32,322**	**$37,393**	**$49,342**
Int. EPS	9	35.4	$18,979	$319	**$13,116**	**$18,231**	**$30,281**	**$32,095**	**$37,210**	**$49,260**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	74.1	$17,119	$668	**$27,455**	**$38,161**	**$63,385**	**$44,574**	**$55,280**	**$80,504**

Table 35. Life cycle cost assessment of large basement in Edmonton – 80% natural gas.

Edmonton - Oil 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	25.8	$21,941	$654	**$26,901**	**$37,391**	**$62,106**	**$48,842**	**$59,332**	**$84,048**
Ext Fibre	9.9	27.5	$21,365	$697	**$28,673**	**$39,855**	**$66,199**	**$50,038**	**$61,220**	**$87,564**
Ext EPS	11.25	26.4	$21,122	$670	**$27,526**	**$38,261**	**$63,551**	**$48,648**	**$59,383**	**$84,673**
Ext SPF	12	25.8	$22,972	$654	**$26,901**	**$37,391**	**$62,106**	**$49,873**	**$60,363**	**$85,079**
Int. Fibre	12	25.3	$19,423	$642	**$26,379**	**$36,666**	**$60,903**	**$45,802**	**$56,089**	**$80,325**
Int. Cell.	12	25.3	$19,500	$642	**$26,379**	**$36,666**	**$60,903**	**$45,879**	**$56,166**	**$80,403**
Int. Batt	20	21.3	$19,770	$540	**$22,209**	**$30,869**	**$51,274**	**$41,978**	**$50,639**	**$71,044**
Int. XPS	10	26.9	$21,349	$682	**$28,048**	**$38,985**	**$64,754**	**$49,397**	**$60,334**	**$86,104**
Int. EPS	9	27.5	$20,679	$697	**$28,673**	**$39,855**	**$66,199**	**$49,352**	**$60,533**	**$86,877**
Int. SPF	12	25.3	$23,135	$642	**$26,379**	**$36,666**	**$60,903**	**$49,514**	**$59,801**	**$84,038**
ICFs	22	19.3	$27,771	$489	**$20,123**	**$27,971**	**$46,459**	**$47,894**	**$55,741**	**$74,230**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	33.9	$18,346	$860	**$35,346**	**$49,130**	**$81,605**	**$53,693**	**$67,476**	**$99,951**
Int. Cell.	12	33.9	$18,385	$860	**$35,346**	**$49,130**	**$81,605**	**$53,732**	**$67,515**	**$99,990**
Int. Batt	20	31.4	$18,521	$796	**$32,740**	**$45,507**	**$75,587**	**$51,261**	**$64,028**	**$94,108**
Int. XPS	10	35.1	$19,317	$890	**$36,597**	**$50,869**	**$84,494**	**$55,915**	**$70,186**	**$103,811**
Int. EPS	9	35.4	$18,979	$898	**$36,910**	**$51,304**	**$85,216**	**$55,889**	**$70,283**	**$104,195**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	74.1	$17,119	$1,879	**$77,261**	**$107,390**	**$178,375**	**$94,380**	**$124,509**	**$195,494**

Table 36. Life cycle cost assessment of large basement in Edmonton – 80% efficiency oil.

Edmonton - Propane 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	25.8	$21,941	$676	**$27,776**	**$38,607**	**$64,127**	**$49,717**	**$60,548**	**$86,068**
Ext Fibre	9.9	27.5	$21,365	$720	**$29,606**	**$41,151**	**$68,352**	**$50,971**	**$62,516**	**$89,717**
Ext EPS	11.25	26.4	$21,122	$691	**$28,422**	**$39,505**	**$65,618**	**$49,544**	**$60,627**	**$86,740**
Ext SPF	12	25.8	$22,972	$676	**$27,776**	**$38,607**	**$64,127**	**$50,748**	**$61,580**	**$87,099**
Int. Fibre	12	25.3	$19,423	$663	**$27,237**	**$37,859**	**$62,884**	**$46,660**	**$57,282**	**$82,306**
Int. Cell.	12	25.3	$19,500	$663	**$27,237**	**$37,859**	**$62,884**	**$46,738**	**$57,359**	**$82,384**
Int. Batt	20	21.3	$19,770	$558	**$22,931**	**$31,873**	**$52,942**	**$42,701**	**$51,643**	**$72,711**
Int. XPS	10	26.9	$21,349	$704	**$28,960**	**$40,253**	**$66,861**	**$50,309**	**$61,603**	**$88,210**
Int. EPS	9	27.5	$20,679	$720	**$29,606**	**$41,151**	**$68,352**	**$50,284**	**$61,830**	**$89,031**
Int. SPF	12	25.3	$23,135	$663	**$27,237**	**$37,859**	**$62,884**	**$50,372**	**$60,994**	**$86,019**
ICFs	22	19.3	$27,771	$505	**$20,778**	**$28,881**	**$47,971**	**$48,549**	**$56,651**	**$75,741**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	33.9	$18,346	$888	**$36,496**	**$50,728**	**$84,259**	**$54,842**	**$69,074**	**$102,606**
Int. Cell.	12	33.9	$18,385	$888	**$36,496**	**$50,728**	**$84,259**	**$54,881**	**$69,114**	**$102,645**
Int. Batt	20	31.4	$18,521	$822	**$33,805**	**$46,987**	**$78,046**	**$52,326**	**$65,508**	**$96,567**
Int. XPS	10	35.1	$19,317	$919	**$37,788**	**$52,524**	**$87,242**	**$57,105**	**$71,841**	**$106,559**
Int. EPS	9	35.4	$18,979	$927	**$38,111**	**$52,973**	**$87,988**	**$57,090**	**$71,952**	**$106,967**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	74.1	$17,119	$1,940	**$79,775**	**$110,884**	**$184,178**	**$96,894**	**$128,003**	**$201,297**

Table 37. Life cycle cost assessment of large basement in Edmonton – 80% efficiency propane.

Edmonton - Electricity 100% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	25.8	$21,941	$710	**$29,168**	**$40,542**	**$67,341**	**$51,109**	**$62,483**	**$89,282**
Ext Fibre	9.9	27.5	$21,365	$756	**$31,090**	**$43,214**	**$71,778**	**$52,455**	**$64,579**	**$93,143**
Ext EPS	11.25	26.4	$21,122	$726	**$29,846**	**$41,485**	**$68,907**	**$50,968**	**$62,607**	**$90,029**
Ext SPF	12	25.8	$22,972	$710	**$29,168**	**$40,542**	**$67,341**	**$52,140**	**$63,515**	**$90,313**
Int. Fibre	12	25.3	$19,423	$696	**$28,603**	**$39,757**	**$66,036**	**$48,025**	**$59,179**	**$85,458**
Int. Cell.	12	25.3	$19,500	$696	**$28,603**	**$39,757**	**$66,036**	**$48,103**	**$59,257**	**$85,536**
Int. Batt	20	21.3	$19,770	$586	**$24,080**	**$33,471**	**$55,595**	**$43,850**	**$53,241**	**$75,365**
Int. XPS	10	26.9	$21,349	$740	**$30,411**	**$42,271**	**$70,212**	**$51,761**	**$63,620**	**$91,561**
Int. EPS	9	27.5	$20,679	$756	**$31,090**	**$43,214**	**$71,778**	**$51,768**	**$63,892**	**$92,456**
Int. SPF	12	25.3	$23,135	$696	**$28,603**	**$39,757**	**$66,036**	**$51,738**	**$62,892**	**$89,171**
ICFs	22	19.3	$27,771	$531	**$21,819**	**$30,328**	**$50,375**	**$49,590**	**$58,099**	**$78,146**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	33.9	$19,256	$932	**$38,325**	**$53,271**	**$88,482**	**$57,582**	**$72,527**	**$107,739**
Int. Cell.	12	33.9	$19,295	$932	**$38,325**	**$53,271**	**$88,482**	**$57,621**	**$72,566**	**$107,778**
Int. Batt	20	31.4	$19,431	$864	**$35,499**	**$49,342**	**$81,957**	**$54,930**	**$68,773**	**$101,389**
Int. XPS	10	35.1	$20,227	$965	**$39,682**	**$55,156**	**$91,615**	**$59,909**	**$75,384**	**$111,842**
Int. EPS	9	35.4	$19,889	$974	**$40,021**	**$55,628**	**$92,398**	**$59,910**	**$75,517**	**$112,287**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	74.1	$17,119	$2,038	**$83,773**	**$116,441**	**$193,409**	**$100,892**	**$133,560**	**$210,528**

Table 38. Life cycle cost assessment of large basement in Edmonton – 100% efficiency electricity.

VICTORIA – Large Basement Life Cycle Cost Assessments

Life cycle cost assessments for large basement systems located in Victoria are presented in Tables 39 through 42. Similar to Halifax and Edmonton, the annual energy demand for the *Ext. Fibre* and the *Int. EPS* basement insulation options are coincidentally equal for the large basement model, resulting in identical life cycle energy costs.

Victoria - Natural Gas 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	14.4	$19,418	$277	**$11,396**	**$15,840**	**$26,310**	**$30,814**	**$35,258**	**$45,728**
Ext Fibre	9.9	15.3	$18,807	$295	**$12,108**	**$16,830**	**$27,954**	**$30,915**	**$35,637**	**$46,761**
Ext EPS	11.25	14.7	$18,550	$283	**$11,633**	**$16,170**	**$26,858**	**$30,183**	**$34,720**	**$45,408**
Ext SPF	12	14.4	$20,510	$277	**$11,396**	**$15,840**	**$26,310**	**$31,906**	**$36,350**	**$46,820**
Int. Fibre	12	14.1	$16,749	$271	**$11,158**	**$15,510**	**$25,762**	**$27,908**	**$32,259**	**$42,511**
Int. Cell.	12	14.1	$16,832	$271	**$11,158**	**$15,510**	**$25,762**	**$27,990**	**$32,341**	**$42,593**
Int. Batt	20	11.9	$17,117	$229	**$9,417**	**$13,090**	**$21,742**	**$26,535**	**$30,207**	**$38,859**
Int. XPS	10	15.0	$18,791	$289	**$11,871**	**$16,500**	**$27,406**	**$30,661**	**$35,290**	**$46,197**
Int. EPS	9	15.3	$18,080	$295	**$12,108**	**$16,830**	**$27,954**	**$30,188**	**$34,910**	**$46,034**
Int. SPF	12	14.1	$20,683	$271	**$11,158**	**$15,510**	**$25,762**	**$31,841**	**$36,192**	**$46,444**
ICFs	22	10.8	$23,986	$208	**$8,547**	**$11,880**	**$19,732**	**$32,533**	**$35,866**	**$43,719**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.0	$14,706	$366	**$15,036**	**$20,900**	**$34,714**	**$29,742**	**$35,606**	**$49,420**
Int. Cell.	12	19.0	$14,745	$366	**$15,036**	**$20,900**	**$34,714**	**$29,781**	**$35,645**	**$49,459**
Int. Batt	20	17.6	$14,881	$339	**$13,928**	**$19,360**	**$32,156**	**$28,809**	**$34,241**	**$47,037**
Int. XPS	10	19.7	$15,677	$379	**$15,590**	**$21,670**	**$35,993**	**$31,267**	**$37,346**	**$51,670**
Int. EPS	9	19.9	$15,339	$383	**$15,748**	**$21,890**	**$36,359**	**$31,087**	**$37,228**	**$51,698**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Gas 80%	N/A	41.1	$13,479	$791	**$32,526**	**$45,209**	**$75,093**	**$46,004**	**$58,688**	**$88,571**

Table 39. Life cycle cost assessment of large basement in Victoria – 80% natural gas.

Victoria - Oil 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	14.4	$19,418	$424	**$17,412**	**$24,202**	**$40,199**	**$36,830**	**$43,620**	**$59,617**
Ext Fibre	9.9	15.3	$18,807	$450	**$18,500**	**$25,715**	**$42,712**	**$37,307**	**$44,522**	**$61,519**
Ext EPS	11.25	14.7	$18,550	$432	**$17,775**	**$24,706**	**$41,037**	**$36,325**	**$43,256**	**$59,587**
Ext SPF	12	14.4	$20,510	$424	**$17,412**	**$24,202**	**$40,199**	**$37,922**	**$44,712**	**$60,709**
Int. Fibre	12	14.1	$16,749	$415	**$17,049**	**$23,698**	**$39,362**	**$33,799**	**$40,447**	**$56,111**
Int. Cell.	12	14.1	$16,832	$415	**$17,049**	**$23,698**	**$39,362**	**$33,881**	**$40,529**	**$56,193**
Int. Batt	20	11.9	$17,117	$350	**$14,389**	**$20,000**	**$33,220**	**$31,506**	**$37,117**	**$50,338**
Int. XPS	10	15.0	$18,791	$441	**$18,137**	**$25,210**	**$41,874**	**$36,928**	**$44,001**	**$60,665**
Int. EPS	9	15.3	$18,080	$450	**$18,500**	**$25,715**	**$42,712**	**$36,580**	**$43,795**	**$60,792**
Int. SPF	12	14.1	$20,683	$415	**$17,049**	**$23,698**	**$39,362**	**$37,732**	**$44,380**	**$60,044**
ICFs	22	10.8	$23,986	$318	**$13,059**	**$18,151**	**$30,150**	**$37,045**	**$42,138**	**$54,136**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.0	$14,706	$559	**$22,974**	**$31,933**	**$53,041**	**$37,680**	**$46,639**	**$67,747**
Int. Cell.	12	19.0	$14,745	$559	**$22,974**	**$31,933**	**$53,041**	**$37,719**	**$46,678**	**$67,786**
Int. Batt	20	17.6	$14,881	$518	**$21,281**	**$29,580**	**$49,133**	**$36,162**	**$44,461**	**$64,013**
Int. XPS	10	19.7	$15,677	$579	**$23,820**	**$33,110**	**$54,995**	**$39,497**	**$48,786**	**$70,672**
Int. EPS	9	19.9	$15,339	$585	**$24,062**	**$33,446**	**$55,553**	**$39,401**	**$48,785**	**$70,892**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Oil 80%	N/A	41.1	$13,479	$1,209	**$49,697**	**$69,076**	**$114,736**	**$63,175**	**$82,555**	**$128,214**

Table 40. Life cycle cost assessment of large basement in Victoria – 80% oil.

Victoria - Propane 80% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	14.4	$19,418	$512	**$21,060**	**$29,273**	**$48,622**	**$40,478**	**$48,690**	**$68,040**
Ext Fibre	9.9	15.3	$18,807	$544	**$22,376**	**$31,102**	**$51,661**	**$41,184**	**$49,909**	**$70,468**
Ext EPS	11.25	14.7	$18,550	$523	**$21,499**	**$29,883**	**$49,635**	**$40,049**	**$48,432**	**$68,185**
Ext SPF	12	14.4	$20,510	$512	**$21,060**	**$29,273**	**$48,622**	**$41,570**	**$49,783**	**$69,132**
Int. Fibre	12	14.1	$16,749	$502	**$20,621**	**$28,663**	**$47,609**	**$37,371**	**$45,412**	**$64,358**
Int. Cell.	12	14.1	$16,832	$502	**$20,621**	**$28,663**	**$47,609**	**$37,453**	**$45,494**	**$64,441**
Int. Batt	20	11.9	$17,117	$423	**$17,404**	**$24,191**	**$40,181**	**$34,521**	**$41,308**	**$57,298**
Int. XPS	10	15.0	$18,791	$534	**$21,938**	**$30,492**	**$50,648**	**$40,728**	**$49,283**	**$69,439**
Int. EPS	9	15.3	$18,080	$544	**$22,376**	**$31,102**	**$51,661**	**$40,456**	**$49,182**	**$69,741**
Int. SPF	12	14.1	$20,683	$502	**$20,621**	**$28,663**	**$47,609**	**$41,304**	**$49,345**	**$68,291**
ICFs	22	10.8	$23,986	$384	**$15,795**	**$21,955**	**$36,466**	**$39,781**	**$45,941**	**$60,453**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.0	$14,706	$676	**$27,788**	**$38,624**	**$64,154**	**$42,494**	**$53,330**	**$78,860**
Int. Cell.	12	19.0	$14,745	$676	**$27,788**	**$38,624**	**$64,154**	**$42,533**	**$53,369**	**$78,899**
Int. Batt	20	17.6	$14,881	$626	**$25,740**	**$35,778**	**$59,427**	**$40,621**	**$50,659**	**$74,308**
Int. XPS	10	19.7	$15,677	$701	**$28,811**	**$40,047**	**$66,518**	**$44,488**	**$55,723**	**$82,194**
Int. EPS	9	19.9	$15,339	$708	**$29,104**	**$40,453**	**$67,193**	**$44,443**	**$55,792**	**$82,532**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**	**LCC of Energy**			**LCC of Basement System**		
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Prop. 80%	N/A	41.1	$13,479	$1,462	**$60,109**	**$83,549**	**$138,775**	**$73,588**	**$97,028**	**$152,254**

Table 41. Life cycle cost assessment of large basement in Victoria – 80% propane.

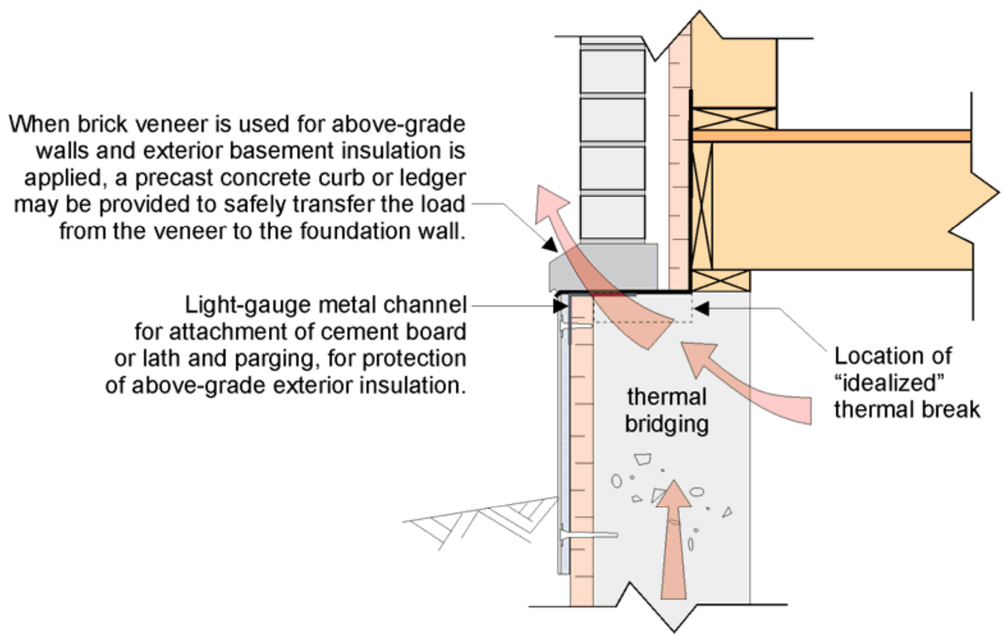
Victoria - Electricity 100% Efficiency, Large Basement										
Class A-3 Basement (Full Height Insulation, Unfinished)										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Ext XPS	12	14.4	$19,418	$279	**$11,461**	**$15,930**	**$26,460**	**$30,879**	**$35,348**	**$45,878**
Ext Fibre	9.9	15.3	$18,807	$296	**$12,177**	**$16,926**	**$28,114**	**$30,984**	**$35,733**	**$46,921**
Ext EPS	11.25	14.7	$18,550	$285	**$11,700**	**$16,262**	**$27,011**	**$30,250**	**$34,812**	**$45,561**
Ext SPF	12	14.4	$20,510	$279	**$11,461**	**$15,930**	**$26,460**	**$31,971**	**$36,440**	**$46,970**
Int. Fibre	12	14.1	$16,749	$273	**$11,222**	**$15,598**	**$25,909**	**$27,972**	**$32,348**	**$42,658**
Int. Cell.	12	14.1	$16,832	$273	**$11,222**	**$15,598**	**$25,909**	**$28,054**	**$32,430**	**$42,741**
Int. Batt	20	11.9	$17,117	$230	**$9,471**	**$13,165**	**$21,866**	**$26,588**	**$30,282**	**$38,984**
Int. XPS	10	15.0	$18,791	$290	**$11,938**	**$16,594**	**$27,563**	**$30,729**	**$35,385**	**$46,353**
Int. EPS	9	15.3	$18,080	$296	**$12,177**	**$16,926**	**$28,114**	**$30,257**	**$35,006**	**$46,194**
Int. SPF	12	14.1	$20,683	$273	**$11,222**	**$15,598**	**$25,909**	**$31,905**	**$36,281**	**$46,591**
ICFs	22	10.8	$23,986	$209	**$8,596**	**$11,948**	**$19,845**	**$32,582**	**$35,934**	**$43,832**
Class B Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Int. Fibre	12	19.0	$14,706	$368	**$15,122**	**$21,019**	**$34,913**	**$29,828**	**$35,725**	**$49,619**
Int. Cell.	12	19.0	$14,745	$368	**$15,122**	**$21,019**	**$34,913**	**$29,867**	**$35,764**	**$49,658**
Int. Batt	20	17.6	$14,881	$341	**$14,008**	**$19,470**	**$32,340**	**$28,889**	**$34,351**	**$47,221**
Int. XPS	10	19.7	$15,677	$381	**$15,679**	**$21,793**	**$36,199**	**$31,356**	**$37,470**	**$51,876**
Int. EPS	9	19.9	$15,339	$385	**$15,838**	**$22,015**	**$36,566**	**$31,177**	**$37,354**	**$51,905**
Class C Basement										
Basement		**Annual**	**Capital**	**Annual**		**LCC of Energy**			**LCC of Basement System**	
Option	**R-Value**	**GJ**	**Cost**	**Energy**	***Low***	***Current***	***High***	***Low***	***Current***	***High***
Elec. 100%	N/A	41.1	$13,479	$796	**$32,711**	**$45,468**	**$75,522**	**$46,190**	**$58,946**	**$89,000**

Table 42. Life cycle cost assessment of large basement in Victoria – 100% electricity.

Energy Impact of Thermal Bridging for Exterior Insulated Basements Supporting Masonry Veneer

Conventionally, only building systems where the exterior insulation can be run continuously over the above and below-grade walls, employ exterior insulated basement systems (EIBS). Builders of masonry veneer houses typically elect an interior basement system insulation option simply because the detailing to support the masonry veneer over an exterior insulated basement is costly and leads to significant thermal bridging as indicated in Figure 8. However, there may be valid reasons where exterior basement insulation is used with masonry veneer above-grade walls, such as[4]:

1. Construction moisture problems associated with vapour permeable interior insulation systems at the above-grade areas of the foundation wall may be avoided through the use of an exterior system.
2. Defects such as water leakage, though significantly reduced, may be repaired easily and cost effectively when exterior systems are employed.
3. In flood prone areas, or areas where municipal sewer surcharge (back-up) are prevalent, exterior systems reduce the costs associated with water damage, and the risks of harmful contaminants (bacteria, moulds, etc.) residing in interstitial spaces of interior systems; and
4. In swelling soils, or soils susceptible to adfreezing, exterior insulation basement systems potentially reduce problems related to surrounding soil movement.



While the use of a lightweight, precast concrete ledger or curb can aesthetically deal with the projection of the exterior basement insulation and protective cover, thermal bridging remains a recognized drawback. Ideally, an insulation material having adequate compressive strength and low creep is needed to eliminate thermal bridging while sustaining the weight of the ledger and brick veneer above.

Figure 8. Thermal bridging associated with exterior insulated basements supporting masonry veneer.

[4] Kesik, T. J.; Swinton, M. C.; Bomberg, M. T.; Kumaran, M. K.; Maref, W.; Normandin, N. *Cost effective basement wall drainage alternatives employing exterior insulation basement systems (EIBS).* Eighth Conference on Building Science & Technology (Toronto, Ontario, 2/22/2001), pp. 377-392, March 01, 2001. http://irc.nrc-cnrc.gc.ca/fulltext/nrcc44756/

As noted in the previous sections, the heat loss modeling of basement systems with exterior insulation assumed no thermal bridging, where siding and stucco type cladding systems provided continuity of exterior insulation over above and below-grade walls. However, in cases where exterior basement insulation was combined with above-grade masonry veneer wall cladding, a limited analysis was conducted to determine the associated energy penalty. The results of this analysis for Toronto, Ontario are presented in Table 43.

Based on the BASECALC™ simulations, thermal bridging depicted in Figure 8 reduced the thermal effectiveness of the insulation by approximately 20%, averaged for small and large basements, compared to exterior insulation systems where thermal bridging was controlled.

For a small basement in Toronto, the average energy demand penalty associated with thermal bridging is 2.3 GJ, a 22.7% increase over the exterior basement insulation options where thermal bridging is controlled. The small basement, when heated by 80% efficiency natural gas equipment, carries an average annual cost premium of $44.25. Life cycle cost premiums range from $1,793 to $4,140 depending on the economic scenario. In the case of 100% efficiency electric heating, the average annual cost premium is $81.25, and the life cycle cost premiums range from $2,549 to $5,885.

For a large basement in Toronto, the average energy demand penalty associated with thermal bridging is 3.4 GJ, an 18.8% increase over the exterior basement insulation options where thermal bridging is controlled. The large basement, when heated by 80% efficiency natural gas equipment, carries an average annual cost premium of $63.50. Life cycle cost premiums range from $2,603 to $6,010. In the case of 100% efficiency electric heating, the average annual cost premium is $90.25, and the life cycle cost premiums range from $3,700 to $8,543.

An set of selective analyses indicated that a similar relationship is observed in the other 4 locations examined in this study, with slightly increased penalties for thermal bridging corresponding to colder climates and higher energy prices, and conversely slightly decreased penalties corresponding to warmer climates and lower energy prices, relative to Toronto.

In general, the energy penalty associated with thermal bridging in exterior insulated basements supporting masonry veneer is significant and carries a relatively high life cycle cost premium. However, it is also important to recognize that with such a high proportion of basements eventually being finished to provide additional livable space, there is a future opportunity to install interior insulation and manage the thermal bridging. Properly arranged and installed, this additional insulation can significantly improve the thermal performance and energy efficiency of the basement system.

Toronto - Small Basement, Class A-3 Basement (Full Height Insulation, Unfinished)

Natural Gas 80% Efficiency

		Thermal Break		Masonry Veneer							
Basement		**Annual**	**Annual**	**Annual**	**Annual**	**Energy Penalty**			**Life Cycle Cost Premium**		
Option	**R-Value**	**GJ**	**Energy**	**GJ**	**Energy**	**GJ**	**Energy**	**%**	**Low**	**Current**	**High**
Ext XPS	12	9.9	$186	12.4	$236	2.5	$50	25.3	$1,928	$2,680	$4,452
Ext Fibre	9.9	10.9	$205	13.1	$246	2.2	$41	20.2	$1,697	$2,359	$3,918
Ext EPS	11.25	10.5	$197	12.6	$236	2.1	$39	20.0	$1,620	$2,251	$3,740
Ext SPF	12	9.9	$186	12.4	$233	2.5	$47	25.3	$1,928	$2,680	$4,452
					Avg.	**2.3**	**$44.25**	**22.7**	**$1,793**	**$2,493**	**$4,140**

Electricity 100% Efficiency

		Thermal Break		Masonry Veneer							
Basement		**Annual**	**Annual**	**Annual**	**Annual**	**Energy Penalty**			**Life Cycle Cost Premium**		
Option	**R-Value**	**GJ**	**Energy**	**GJ**	**Energy**	**GJ**	**Energy**	**%**	**Low**	**Current**	**High**
Ext XPS	12	9.9	$186	12.4	$264	2.5	$78	25.3	$2,741	$3,810	$6,328
Ext Fibre	9.9	10.9	$205	13.1	$291	2.2	$86	20.2	$2,412	$3,353	$5,569
Ext EPS	11.25	10.5	$197	12.6	$280	2.1	$83	20.0	$2,302	$3,200	$5,316
Ext SPF	12	9.9	$186	12.4	$264	2.5	$78	25.3	$2,741	$3,810	$6,328
					Avg.	**2.3**	**$81.25**	**22.7**	**$2,549**	**$3,543**	**$5,885**

Toronto - Large Basement, Class A-3 Basement (Full Height Insulation, Unfinished)

Natural Gas 80% Efficiency

		Thermal Break		Masonry Veneer							
Basement		**Annual**	**Annual**	**Annual**	**Annual**	**Energy Penalty**			**Life Cycle Cost Premium**		
Option	**R-Value**	**GJ**	**Energy**	**GJ**	**Energy**	**GJ**	**Energy**	**%**	**Low**	**Current**	**High**
Ext XPS	12	17.6	$330	21.0	$394	3.4	$64	19.3	$2,623	$3,645	$6,055
Ext Fibre	9.9	18.8	$353	22.1	$415	3.3	$62	17.6	$2,545	$3,538	$5,877
Ext EPS	11.25	17.9	$336	21.3	$400	3.4	$64	19.0	$2,623	$3,645	$6,055
Ext SPF	12	17.6	$330	21.0	$394	3.4	$64	19.3	$2,623	$3,645	$6,055
					Avg.	**3.4**	**$63.50**	**18.8**	**$2,603**	**$3,618**	**$6,010**

Electricity 100% Efficiency

		Thermal Break		Masonry Veneer							
Basement		**Annual**	**Annual**	**Annual**	**Annual**	**Energy Penalty**			**Life Cycle Cost Premium**		
Option	**R-Value**	**GJ**	**Energy**	**GJ**	**Energy**	**GJ**	**Energy**	**%**	**Low**	**Current**	**High**
Ext XPS	12	17.6	$469	21.0	$560	3.4	$91	19.3	$3,728	$5,182	$8,607
Ext Fibre	9.9	18.8	$501	22.1	$589	3.3	$88	17.6	$3,618	$5,029	$8,353
Ext EPS	11.25	17.9	$477	21.3	$568	3.4	$91	19.0	$3,728	$5,182	$8,607
Ext SPF	12	17.6	$469	21.0	$560	3.4	$91	19.3	$3,728	$5,182	$8,607
					Avg.	**3.4**	**$90.25**	**18.8**	**$3,700**	**$5,143**	**$8,543**

Table 43. Energy penalty associated with exterior insulation of basements supporting masonry veneer, selected cases for Toronto.

SYNOPSIS

The life cycle assessment of basement insulation options is a necessary but insufficient examination of all the factors that need to be carefully considered when selecting among alternatives. There are numerous non-monetary considerations that may be more important for the marketability and habitability of residential basements. Some of the most notable include:

- costs of damage from sewer backup or flooding and associated increases in premiums or refusals of insurance protection – a major problem in finished basements with water absorbing insulation;
- susceptibility to mold growth and associated health risks arising from moisture migration within wall assemblies constructed using vapour permeable insulation materials;
- ease of remediation for callbacks due to water leakage for exterior insulation options; and
- conservation of thermal mass in externally insulated basements serving as a freeze protection buffer during power blackouts.

For these reasons, selecting the most cost effective insulation option may not always translate into the best choice when all related performance factors are fully considered.

Conclusions

Based on the findings of this update study, the following conclusions were drawn from the findings:

1. The assumption made in the original study that measures that were cost effective in a small basement would be even more cost effective in a larger basement has been proven correct. The life cycle cost per unit floor area for large basement systems is lower than for small basements because for simple basement geometries, the basement envelope area does not increase linearly with floor area.
2. In all locations, irrespective of the thermal/moisture protection option selected, Class A-3 basements (full-height insulation with proper moisture protection) delivered the lowest energy and total life cycle costs. Class B basements (partial-height insulation) and Class C basements (uninsulated cellars) are not cost effective to consumers of housing under any energy pricing scenario.
3. For all types and sizes of basements assessed in this study, the lowest life cycle energy cost was associated with basements constructed using insulating concrete forms (ICFs).
4. For all types and sizes of basements assessed in this study, the lowest total life cycle cost was associated with basements insulated internally, full-height to a nominal level of R-20 (RSI 3.52).
5. Where thermal bridging at the basement wall and floor header intersection is controlled, the annual energy demand and operating energy costs for externally versus internally insulated basements are practically equivalent. Life cycle costs for externally insulated basements are marginally higher than basements internally insulated to the same nominal thermal resistance. The difference is largely due to the higher installed cost of external insulation.
6. In basements with exterior insulation supporting masonry veneer, thermal bridging effects at the basement wall and floor header intersection are significant, resulting on average in a 20% increase in the annual energy demand and operating energy costs over the corresponding case where thermal bridging is controlled. This study did not examine a complete floor slab and wall system insulation wrap strategy, but for basements heated with in-floor hydronic systems, the control of thermal bridging may prove to be a critical practice for life cycle cost effectiveness.
7. There is considerable justification for reviewing the cost effective levels of thermal insulation for basement systems in regulatory codes and standards governing residential energy efficiency in Canada due to the sharp escalation in energy prices recently experienced and forecasts of the continuation of this trend well into the foreseeable future.

Recommendations

The selection of a suitable basement insulation option is largely governed by the intended use of the basement. Within the spectrum of site conditions encountered by builders across the country, there can be large lot sizes and natural slopes that allow surface drainage away from the house in all directions, local soils can be free draining and stable, the water table can be well below the footings, and the local climate can be relatively dry most of the time. In such conditions, a very basic basement configuration meeting minimum code requirements can perform adequately using any of the basement insulation options assessed in this study. Nevertheless, it is improbable that all of those favourable conditions exist at every construction site. As a result, when the builder (and subsequently the homeowner) is dealing with one, some or many challenging conditions in a given location, consideration has to be given to additional measures that may be needed beyond the code minimum to compensate for those challenging site conditions. In most cases, exceeding minimum code requirements will be necessary to achieve acceptable levels of performance corresponding to modern consumer expectations, especially for fully finished, liveable basements.

In view of the life cycle cost assessments, and the related published work on basement performance problems, Table 44 presents the recommended basement insulation options for new and existing homes. Note that in all cases, full-height basement insulation is recommended over all other configurations, and it assumed that construction moisture has dried out prior to interior insulation application.

Soil/Sewer Condition	New	Existing
Well drained soil, no sewer back-up problems	Any option*	Any interior option 5 - 10
Poorly drained soil, poor site drainage	Exterior options 1 – 4 and 11 preferred	Non-vapour permeable interior insulation options 8 or 10 recommended
Rising water table, some sewer backup problems	Exterior options 1 – 4 and 11 recommended	Exterior options 1 – 4 recommended
Flooding and/or chronic sewer back-up problems	Exterior options 1 – 4 and 11 only	Exterior options 1 – 4 only

* Refer to Table 45 for description of basement insulation options.

In existing basements, water leaks and sewer backup problems should be corrected prior to insulating. Refer to *Practical Measures for the Prevention of Basement Flooding Due to Municipal Sewer Surcharge: Final Report*, by T. Kesik and Kathryn Seymour, Canada Mortgage and Housing Corporation, 2003. *(External Research Program Research Report) 95 pages*.

For related information, refer to:
Molds in Finished Basements, 1996. Prepared by Scanada Consultants for CMHC.
Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report. NRC-IRC, 2005.

Table 44. Recommended basement insulation options for new and existing homes.

Insulation Option	Abbreviation	Thermal Resistance
1 - Exterior extruded polystyrene - 2-1/2"	Ext XPS	R-12 (RSI 2.11)
2 - Exterior glass/mineral fibre - 3"	Ext Fibre	R-9.9 (RSI 1.74)
3 - Exterior expanded polystyrene - 3"	Ext EPS	R-11.25 (RSI 1.98)
4 - Exterior sprayed polyurethane foam - 2"	Ext SPF	R-12 (RSI 2.11)
5 - Interior glass/mineral fibre - 3-1/2"	Int. Fibre	R-12 (RSI 2.11)
6 - Interior cellulose - 3-1/2"	Int. Cell.	R-12 (RSI 2.11)
7 - Interior glass/mineral fibre - 5-1/2"	Int.Batt.	R-20 (RSI 3.52)
8 - Interior extruded polystyrene - 2"	Int. XPS	R-10 (RSI 1.76)
9 - Interior expanded polystyrene - 2-1/2"	Int EPS	R-9.4 (RSI 1.66)
10 - Interior sprayed polyurethane foam - 2"	Int. SPF	R-12 (RSI 2.11)
11 - Insulated concrete forms (generic)	ICFs	R-22 (RSI 3.87)

Table 45. Description of basement insulation options assessed in this study.

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