IMPLICATIONS OF ADOPTING THE NATIONAL ENERGY CODE FOR HOUSING IN ONTARIO

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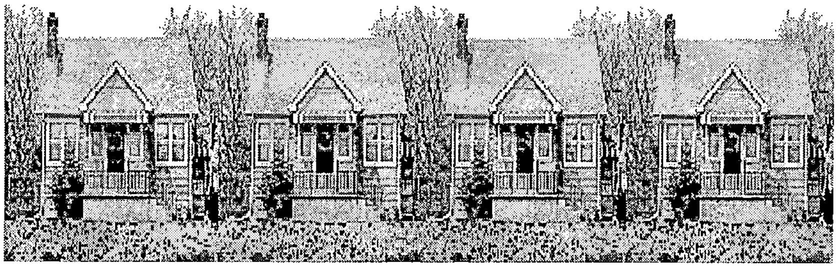
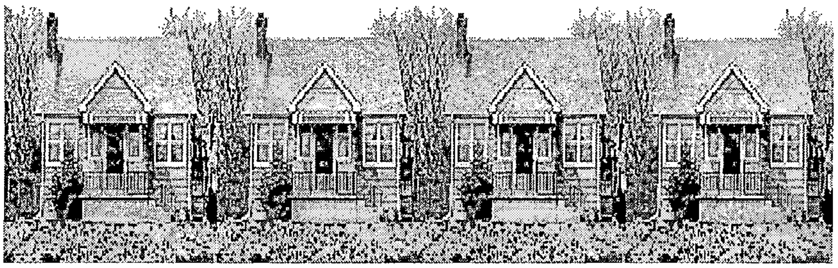
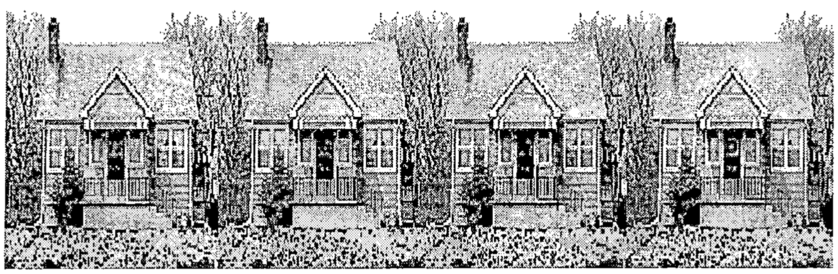




Implications of Adopting the National Energy Code For Housing in Ontario



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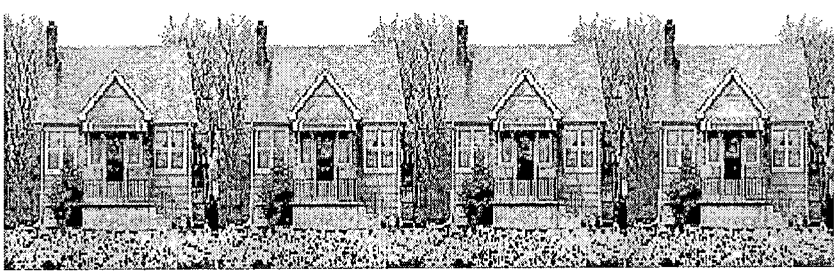

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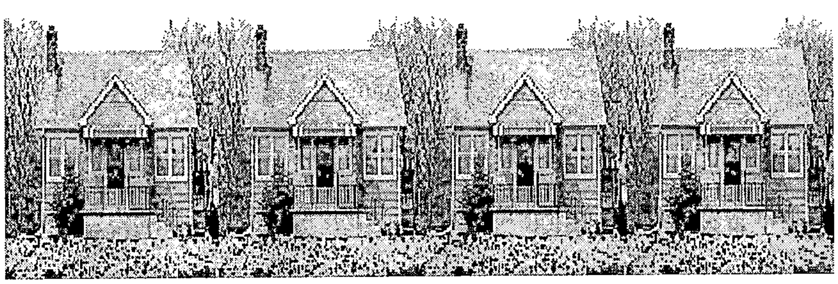

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Executive Summary

This study examines a broad range of implications associated with the adoption of the National Energy Code for Housing (NECH) in Ontario. It is based on Public Review Draft 1.0 of the NECH. This study compares the OBC and the NECH providing commentary on key differences between the documents. It examines the energy, environmental and industry implications of adopting the NECH in Ontario. It reviews the cost implications of adoption from a capital, energy and life cycle viewpoint while examining environmental costs by monetizing space heating equipment emissions. A number of technical issues are examined by this report in relation to specific NECH requirements. Finally, adoption issues are presented as identified by two focus groups comprised of industry and enforcement officials.

The NECH differs in structure from the present provisions for energy efficiency in the Ontario Building Code (OBC) in that it is a companion document to the National Building Code (NBC), whereas requirements for energy efficiency in new housing are integral to Part 9 of the OBC. Its adoption would imply a major revision to the current version of the OBC.

The NECH contains a number of positive aspects including specific improvements over the current version of the OBC. However, for the large majority of Ontario houses, the energy and environmental benefits of fully adopting the NECH are marginal in relation to the most recent requirements for energy efficiency adopted by the OBC in 1993. Negative implications for builders and Code enforcement officials, based on focus group feedback, were viewed as outweighing any potential benefits.

A general consensus among stakeholders indicates that positive aspects of the NECH be incorporated into Part 9 of the OBC, while the trade-off and performance compliance paths of the NECH be referenced in OBC Section 9.38, Thermal Design.

This study recommends that further consultation with specific affected stakeholders is needed prior to any form of NECH adoption, and that in the future, the process undertaken in this study be carried out on a continuous basis to permit broader participation in the development of OBC and energy related requirements in Ontario.

Résumé

L'étude fait le point sur un grand nombre d'incidences associées à l'adoption en Ontario du Code national de l'énergie pour les habitations (CNEH), en s'appuyant sur l'ébauche du rapport de l'examen public 1.0 du CNEH. On compare dans le rapport le Code de bâtiment de l'Ontario (CBO) et le CNEH, et des commentaires sont apportés sur les principales différences entre les deux documents. Les conséquences de cette adoption sur le plan de l'énergie, de l'environnement et de l'industrie en Ontario sont examinées. On évalue les coûts liés à l'adoption dans l'optique des capitaux, de l'énergie et du cycle de vie, tout en examinant les conséquences environnementales par une estimation des coûts liés aux émanations des équipements de chauffage. Un certain nombre de questions techniques sont examinées en relation avec certaines exigences particulières du CNEH. Enfin, on présente des questions relatives à l'adoption soulevées par deux groupes de discussion composés de gens de l'industrie et de responsables de l'application du Code.

Le CNEH diffère des dispositions actuelles visant l'efficacité énergétique dans le CBO en ce sens qu'il va de pair avec le Code national du bâtiment du Canada (CNBC), tandis que les exigences relatives à l'efficacité énergétique pour les nouvelles maisons sont partie intégrante de la Partie 9 du CBO. Son adoption supposerait une révision importante de la version actuelle du CBO.

Le CNEH contient un certain nombre d'aspects positifs, notamment certaines améliorations par rapport à l'actuelle version du CBO. Cependant, pour la grande majorité des maisons en Ontario, les avantages énergétiques et environnementaux d'une adoption globale du CNEH sont marginaux en considération des récentes exigences d'efficacité énergétique adoptées dans le CBO en 1993. Les aspects négatifs pour les entrepreneurs et les responsables de l'application du Code, selon les groupes de discussion, dépassent largement tous les avantages potentiels.

Selon un consensus général chez les intervenants, les aspects positifs du CNEH devraient être incorporés à la Partie 9 du CBO, tandis que les éléments du CNEH touchant le compromis technique et la conformité de rendement devraient faire l'objet d'une référence dans la section 9.38 du CBO concernant la conception thermique.

Cette étude recommande de pousser plus avant la consultation auprès de certains intervenants concernés avant toute adoption du CNEH et, à l'avenir, de poursuivre sur une base continue le processus engagé dans le cadre de cette étude afin de permettre une plus grande participation au développement du CBO et des exigences relatives à l'énergie en Ontario.

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1. INTRODUCTION

The Canadian Commission on Building and Fire Codes will publish a model National Energy Code for Houses (NECH) in the spring of 1996. If adopted by the provinces, the Code will require that all new houses meet or exceed minimum standards for energy efficiency. The NECH provides for each province or territory to have its own minimum standards, taking into account climate and regional energy and construction costs. In other words, the requirements for colder areas in the country and for houses heated with more expensive fuels or electricity are more stringent.

The NECH will apply to all new buildings of residential occupancy that currently conform to the height and building area limits of Part 9 of the National Building Code; that is, buildings that are three storeys or less in height and that have a building area that does not exceed 600 m^2 (6450 ft^2). The NECH does not apply to buildings where heating equipment is not installed, such as summer cottages.

The scope of the National Energy Code for Houses includes requirements for the building envelope, lighting, heating, ventilating and air conditioning systems, service water heating systems and electric power requirements.

Since 1986, Ontario has used a methodology similar to that used to develop the NECH for the development of the insulation requirements of the provincial Code. In 1993, the Ontario Building Code (OBC) adopted insulation provisions based on a life cycle costing approach similar to that of the NECH.

This study seeks to examine the requirements of the National Energy Code for Housing (Version 1.0) and the 1990 Ontario Building Code (with 1993 amendments), identifying differences in approach and finally identifying the implications of adopting the NECH for Ontario.

Specifically this study:

1. Identifies differences between the energy efficiency provisions of the proposed 1995 National Energy Code for Housing (Version 1.0) and the 1990 Ontario Building Code (including the 1993 revisions). For comparison purposes, the prescriptive compliance path of the NECH is used. The study also documents the economic assumption used as part of the development of the NECH. This includes interest rate assumptions, fuel and energy price escalation curves, study periods etc. It also determines the extent to which the NECH provision have responded to energy price externalities and the extent to which these have been embodied within the methodology used to determine the NECH requirements. A commentary is provided on these economic assumptions.

2. Identifies capital cost implications for the homebuyer should the National Energy Code for Housing be adopted in Ontario. It will itemize costs associated with NECH requirements that vary from current OBC requirements, or widespread practice. The analysis of cost will focus primarily on the building envelope, space heating systems and mechanical ventilation systems.

3. Identifies typical annual energy savings (costs) that might result if the NECH were adopted for six benchmark houses (i.e. large two storey (2100 ft2), small two storey (1320 ft2), semi-detached (1470 ft2), row (interior and end) (1080 ft2), small bungalow (1320 ft2), in two degree day locations: Toronto (<5000 DD) and Sault Ste Marie (>5000 DD).

4. Identifies life cycle savings (costs) that might result if the NECH were adopted for the houses noted above. A cost benefit analysis is conducted to examine in detail the simulated lifecycle savings (costs) of each OBC benchmark house configuration compared to its NECH counterpart. Differences between the building envelope, space heating equipment, domestic hot water equipment, lighting and electrical power requirements were examined independently. By this means, differences between NECH and OBC requirements may be individually attributed to changes in the efficiency of the building envelope, mechanicals, lights and appliances. Life cycle cost savings will be calculated based on economic assumptions used in Ontario in past studies and determined in consultation with Ontario Hydro, the Ontario Ministry of Environment and Energy, the Ontario Ministry of Housing and provincial natural gas utilities. In some cases, this study identifies the NECH upgrades that are cost effective for the new home buyer.

5. Identifies impacts to emissions associated with NECH adoption in Ontario. The monetization of externalities is currently the focus of much work in Ontario. At this point consensus approaches to this issue have not emerged. The study will nonetheless quantify greenhouse gas production and other emission implications of NECH adoption in Ontario for all benchmark houses. The benefits are calculated but are not included within the final cost benefit analysis. Other benefits which are not easily quantifiable will also be discussed.
6. Details issues and barriers relating to NECH adoption in Ontario. Issues to be examined include: enforcement implications of NECH adoption; implications for training and education; industry impacts, particularly window and heat recovery ventilators; examination of fuel choice and envelope requirements; and load impacts of set back thermostats. The study evaluates the feasibility of referencing the NECH within the Ontario Building Code.
7. Provides recommendations for NECH adoption or incorporation as part of the Ontario Building Code. The study provides specific recommendations for future Ontario Building Code changes.

The large number of issues related to the adoption of the NECH has required further and more detailed consideration than has been summarized above. These issues are discussed on the pages which follow.

Critical Issues

A number of critical issues related to the adoption of the NECH are identified and discussed below:

Enforcement Requirements

The study reviews how the OBC is currently enforced and what may be required by the NECH. The study focuses on compliance to the prescriptive path option within the NECH. It discusses the implications for municipalities for enforcement of the NECH. Issues examined include:

- How are the OBC energy requirements currently enforced?
- What are the specific enforcement issues that arise from adoption of the NECH ? How would an NECH prescriptive path be enforced? How would an NECH trade-off path be enforced? How would an NECH performance path be enforced?
- Are the Thermal Design requirements of Part 9 currently used by the industry? What approach do municipalities currently use to measure compliance? Is site review currently part of the Thermal Design requirements?
- Are municipalities equipped to enforce the NECH requirements examining both prescriptive and trade-off/performance path compliance?
- What information (e.g., labelling) would the industry need to provide to facilitate enforcement?
- What infrastructure is required to permit the referencing of the NECH in the OBC (including training requirements)?
- Are there aspects of the NECH that are subject to interpretation problems?

Views from builders and of municipal officials have been solicited by way of focus groups, and later presented in relation to these issues.

First Costs to Builders

Every Code change cycle in the past decade has seen the capital cost of dwellings increase. At the same time these are often coupled to operating cost trade-offs. Some increases in first cost are associated with the provision of additional or higher quality materials and equipment. Others are associated with improved quality assurance on the construction site. Specific first costs issues which are examined include:

- What are the economic implications of Code changes in general, in terms of training and education, dealing with builders, suppliers and building officials?
- What threshold of increased capital costs represents economic hardship within the homebuilding industry?
- Are increased first costs associated with more permanent and less easily upgradeable aspects of the dwelling, like the building envelope, more acceptable than increased costs associated with easy to upgrade features like setback thermostats and exterior lighting?
- How will the industry respond to the implicit requirement for airtightness testing within the NECH?
- Will builders pursue the performance or trade-off paths to save money?

Trade-offs

The NECH permits compliance through a performance path and a trade-off path. This study examines the impact of permitting trade-offs particularly as they relate to minimum levels of thermal insulation required to provide acceptable thermal comfort and condensation control. Due to the minimum efficiencies required under the NECH for space heating equipment and heat recovery ventilators, significant trade-offs which compromise the thermal performance of the building envelope may be permitted. This may be particularly problematic when domestic water heating and envelope airtightness are factored into the trade-off assessment.

Wood Heating

The NECH has grouped Electricity with "Other" fuel types into one category. Application of the NECH would mean, for example, the envelope requirements are the same for wood heated houses as those heated with electricity. The study reviews the rationale that led to this requirement. It also examines the implications of the requirement on the home building industry and the wood heating industry.

Dual Fuel

NECH allows the use of a secondary fuel for space heating (dual fuel), provided the alternate fuel does not account for more than 10% of the total space heating requirement. Issues examined by the study include: What impact will this have in the Ontario marketplace? Would supplemental baseboard heating be permitted under the NECH rules? Will this reversal of the current Ontario Building Code requirement for non-electric houses of currently accepting no supplemental electric heating, be detrimental to the Code's credibility?

Window Standards

The NECH would require more energy efficient windows for all housing. This study examines the impact on the window industry if the NECH were referenced within the OBC. Specific issues examined include:

- Can manufacturers meet the anticipated production/volume required?
- Will the industry be able to get enough windows tested and labelled?
- What are the enforcement implications if the Ontario Ministry of Environment and Energy adds windows to their EE Act, requiring all windows be certified and labelled.
- Will the window requirements subsequently be regulated in Ontario through the OBC or the EE Act?

Key informant interviews were conducted with selected Ontario manufacturers to assess the impact of NECH adoption and EE Act revisions.

Heat Recovery Ventilators

The NECH will require heat recovery ventilators (HRVs) for all fuel types in Zone 2 and for all electrically heated houses in Zone 1. The study examines the impacts on the industry of this requirement. It will examine production and/or labelling issues that may impinge orderly implementation. The study also examines the electrical load implications for Ontario Hydro of the HRV requirements.

Other less critical issues will also be addressed throughout the report as they arise.

Future Directions

Following all analyses and the examination of critical issues, this study examines the future direction of residential energy efficiency requirements in building codes. Given that the intent of the NECH, or for that matter the OBC, is not explicitly stated in this regard, key elements of the evaluative framework and processes needed to deal with the evolution of Code requirements for energy efficiency are presented.

2. Comparison of the NECH to the OBC

The 1990 and 1993 amendments to the Ontario Building Code include energy efficiency provisions mandating full height basement insulation, the differentiation of insulation requirements based on the energy source for heating, increased standards for window efficiency (particularly in electrically heated homes) and differentiated insulation provisions based on climatic zone. The approach used to develop these provisions was based on a life cycle cost analysis that considered not only the cost of energy but also the capital cost of the energy efficiency measure, the costs associated with maintenance and repair of the measure and its expected life span.

The proposed National Energy Code for Housing also uses a life cycle costing approach in developing requirements for the building envelope, lighting, heating, ventilating and air conditioning (HVAC), service water heating and the provision of electrical power. In addition, the requirements of the NECH extend to aspects of the home that are not currently regulated within the Ontario Building Code. Each of these has been summarized on the pages which follow.

The energy provisions of the Ontario Building Code are contained primarily in Section 9.25. This section outlines the requirements for thermal insulation and the control of condensation in houses. In addition, the OBC also includes Section 9.38 *Thermal Design* which is available as an alternative to the provisions of Section 9.25.

The comparison that follows focuses on the requirements of the NECH (review version 1.0) and compares these qualitatively to the OBC's energy provisions as outlined in OBC Sections 9.25 and 9.38.

Scope, Definitions And General Requirements

Scope and Definitions

The NECH is intended to regulate buildings of residential occupancy that fall within the scope of Part 9. In addition, the NECH provisions for building envelopes only apply to buildings intended for year-round use.

NECH APPENDIX NOTE:
It is often difficult to identify a "seasonal" dwelling; i.e. a dwelling intended to be used only in summertime. Generally, if a dwelling has a space heating system installed or incorporates provisions for future installation of a space heating system, it should be considered to fall within the scope of this Part.

Prescriptive, Trade-Off and Building Energy Performance Compliance

The General Requirements of the NECH identify the approaches to compliance as three paths with common mandatory provisions. The three compliance paths used by the NECH are:

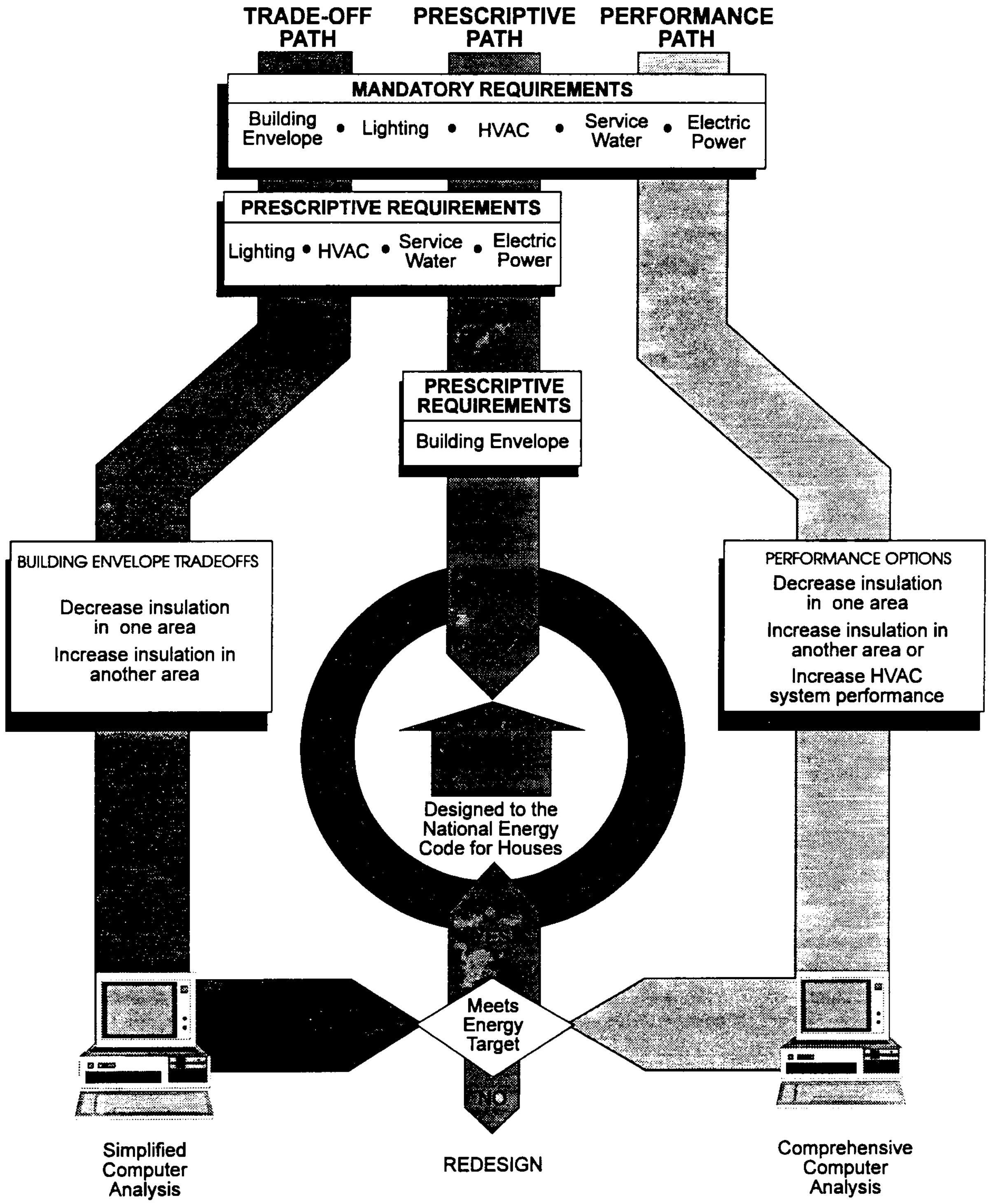
- a prescriptive path where the energy requirements for the house are prescribed;
- a trade-off path that permits for instance using less insulation in one envelope component provided more insulation is used in another; and
- a performance path that makes use of a computer program as a means of testing compliance with the NECH requirements. (See Figure 1).

Basic Data and Calculation Methods

The NECH references climatic data from the OBC for Ontario. The NECH suggests other sources for this information in the absence of OBC data.

Both Codes establish thermal characteristics of building assemblies based on two degree-days zones for the province. The NECH's Zone A (same as Zone 1 in the OBC) includes all regions of less than 5000 degree-days while Zone B (same as Zone 2 in the OBC) includes all regions with degree-days greater than or equal to 5000 degree-days.

Figure 1
NECH Compliance Paths



Adapted from: National Energy Code for Houses, Natural Resources Canada

In addition to being differentiated based on climate, the NECH is also differentiated based on the energy source for space heating. The NECH contains envelope requirements specific to houses in three groups. These correspond to houses heated with:

1. natural gas or with ground source heat pumps;
2. oil, propane or air source heat pumps;
3. electricity or other fuels (e.g. wood heating).

The Ontario Building Code is also differentiated based on fuel type. The OBC does not contain the degree of differentiation of the NECH. The OBC only requires higher levels of envelope insulation for houses that are heated by electrical means. These houses also need to be equipped with more energy efficient windows and with heat recovery ventilators.

Thermal Resistance and Envelope Areas

The thermal characteristics of building assemblies within the NECH are derived from the Appendices of the Energy Code or from acceptable lab tests. It should be carefully noted that the insulation levels referenced in the NECH are effective thermal resistances for above grade opaque envelope components and effective added thermal resistance for below grade components.

The effective thermal resistance and the effective added thermal resistance include the effects of structural framing. All envelope components (including air films) within the envelope assembly are accounted for as part of the calculation of effective thermal resistance. Effective added thermal resistance only considers those components that are added to the uninsulated below grade envelope and again also account for thermal bridging through framing.

The following techniques were used to evaluate the thermal characteristics of the building assemblies in the NECH:

Table 2.1
Evaluation Method of Thermal Characteristics for the NECH

House Assembly	Thermal Characteristics	Method
Insulated wood frame wall and roof assemblies	Effective Thermal Resistance	ASHRAE parallel heat flow method
Below grade assemblies	Added Effective Thermal Resistance	ASHRAE parallel heat flow method for the insulated and framed portion only
Fenestration	ER and overall U-value, SHGC	CSA A440.2, using Vision and Frame

The application of the OBC's insulation requirements generally only involve the determination of the thermal resistance of the added insulation without consideration of other envelope components (air films, interior or exterior finishes, etc...) or thermal bridging as might result from framing members.

The thermal and solar characteristics of windows within the NECH are based on CAN/CSA-A440.2 *"Energy Performance Evaluation of Windows and Sliding Glass Doors"*. The thermal characteristics of windows and sliding glass doors that are beyond the scope of A440.2 may be derived from Appendix B of the NECH, from the ASHRAE Fundamentals or from acceptable laboratory testing.

The OBC provides specific requirements for the thermal resistance windows in non-electrically heated houses and references A440.2 for the windows in electrically heated houses. For non-electrically heated houses the OBC is not specific as to how the window thermal resistance should be derived (i.e. centre of glass, overall thermal resistance, inclusive of frame, etc...).

Equivalents

The NECH includes provisions for use of equivalents where evidence is submitted (presumably to the authority having jurisdiction); evidence based on past performance, test or evaluation.

Building Envelope

General

The NECH building envelope provisions consist of requirements that address insulation and airtightness. The NECH specifies the insulation requirements both in terms of thermal resistance and in terms of installation.
The insulation requirements of the NECH also describe the nature of the windows that are required to fulfil compliance.

Continuity of Insulation

The NECH addresses in specific terms the continuity of insulation at service penetrations and at intersections between building components.

The NECH requires special attention be paid to service penetrations, particularly where the service penetrations might adversely affect the insulative properties of the envelope. Continuity of the insulation is required at penetrations or around pipes and ducts. These services are required to be on the warm side of the insulation and must not compress or reduce the insulation beyond the specified code minimums.

The NECH requires that chimneys, partitions and fireplaces not break the continuity of the insulation. Intersections between components (e.g. walls and floors, walls and ceilings) must also be insulated.

The only exception to the continuity provisions of the NECH are at studs and at joists in wood frame construction. The effects of these frame elements are accounted for as part of the effective thermal resistance value for the component presented in the NECH Appendix.

The OBC is less specific about insulation continuity with only Article 9.25.4.1 addressing this issue in any way.

Insulation Requirements

The insulation requirements of the OBC and NECH are compared below. Both documents present insulation values differentiated by space heating fuel type and by climate. With minor differences the Codes address the same components of the building envelope.

One difference between the two documents involves the NECH requirement for houses heated with radiant heating where the heating pipes, cables or membranes are installed in the building envelope. In these buildings, all of the NECH envelope insulation levels must be increased by 20%. There is no similar provision within the OBC.

Tables 2.2, 2.3 and 2.4 below are extracted from the NECH and the OBC. Carefully note that direct comparison between the two documents is not possible given the NECH reference to effective thermal resistance. Comparing the two documents requires assumptions for the construction of all envelope components. Section 3 of this report presents construction assemblies selected to best represent the NECH requirements. These are used as the basis for the qualitative comparison below.

Ceilings and Roofs

The NECH has a useful definition of roof assembly not contained in the Ontario Building Code. Roofs are defined as the envelope elements less than 60 degrees from the horizontal.

The insulation requirements at the roof eave differ from the current version of the OBC. The roof eave insulation must not be less than that required at the wall of the house.

In general, the NECH requires higher levels of attic and roof insulation for Zone 1 and Zone 2 houses in Ontario than the Ontario Building Code. The largest difference exists in attic ceilings in electrically heated houses. Attic and roof insulation requirements for houses heated with natural gas are similar in both codes.

Above Grade Walls

The requirements for wall insulation are similar in both codes. Only minor differences exist and are primarily limited to walls for houses equipped with heat pump systems.

The NECH requires header areas to be insulated to the same nominal value as exterior walls. In other words, thermal bridging differences between floor and wall framing are ignored.

Building Assemblies in Contact with the Ground

All foundation walls are required to be insulated full height on the interior, on the exterior or a combination of both in both the NECH and the OBC.

The NECH insulation provisions for foundation walls apply only to walls less than 1.2 m (4 feet) above grade. Foundation walls greater that 1.2 m (4 feet) above grade are subject to the requirements for above grade walls. Where deep foundations are present insulation is not required 8 feet below grade. These distinctions are not made within the OBC.

The foundation wall insulation requirements of the NECH are similar to those of the OBC. The NECH requirements are somewhat higher for oil and propane-heated houses. The foundation wall insulation requirements for gas heated houses are comparable.

Foundation walls that are partially insulated on the inside and partially insulated on the outside are required to have an insulation overlap of 4x the thickness of the wall. This provision differs from the recommended practice in Ontario of 2x the wall thickness.

Floors

The NECH insulation requirements for conventional wood joist floor systems exposed to weather are similar to those of the OBC with exception to the requirements for floors in electrically-heated houses. These requirements are somewhat higher in the NECH.

Windows and Other Glazed Areas

All glazed areas are accounted for within the NECH including sliding glass doors, sidelites and glazing that is part of doors.

The NECH limits the amount of glazing in the house to no more than 20% of the floor area of the house excluding crawlspaces, most basements and storage garage. It also provides some relief to south-facing windows that meet specific conditions. Only 50% of south-facing window area is used in the 20% floor area calculation provided:

- the windows face within 45° of South;
- the solar heat gain coefficient of windows exceeds 0.58 (SC=0.7, SHGC=SCx0.83);
- the windows are unshaded (or the portion to get the relief is unshaded) at noon December 21;
- provisions are made within the building to distribute the heat gain from the glazing throughout the building; and
- if the building is cooled the windows are shaded at noon June 21.

The requirements for windows are generally higher within the NECH than within the OBC. For electrically-heated houses in both degree-day zones, the NECH requirement for operable windows is ER -10 versus ER -13 for the OBC. The requirements for fixed windows are identical (ER 0) in both documents. In practical terms the differences for operable windows imply double-glazed low-E for the OBC versus double-glazed low-E argon-filled for the NECH.

The OBC window requirements for non-electrically heated houses unlike the NECH quote thermal resistance rather than ER ratings. For gas, oil and propane-heated houses the practical differences between the two documents translates into double glazed units for the OBC and double-glazed low-E for the NECH regardless of degree-day zone.

Table 2.2
NECH Insulation Requirements - Ontario Zone A Houses

NECH Table 2.2.3.A. - Energy Source Adjustment Factors

Principal Heating Source	Electricity	Propane	Oil	Natural Gas	Heat Pump Electric	Other
Energy Source Adjustment Factor	1	0.4	0.4	0.24	0.5 (as)* 0.33 (gs)*	1
Column 1	2	3	4	5	6	7

* (as) - air source heat pump; (gs) - ground source heat pump

Tables of Prescriptive Requirements	**PRINCIPAL HEATING SOURCE**		
	Electricity, Other	Oil, Propane, Heat Pump (as)	Natural Gas Heat Pump (gs)
NECH Table 3.3.1.A. - Above Ground Building Assemblies	**Minimum Effective Thermal Resistance** m².°C/W (ft².°F.h/BTU)		
Roofs Type I - attic-type	9.0 (51.1)	7.2 (40.9)	5.8 (32.9)
Type II - all others (e.g. roof-joist)	5.2 (29.5)	3.3 (18.7)	3.3 (18.7)
Walls	4.4 (25)	3.0 (17)	2.9 (16.5)
Floors Type I - truss-type (open web)	9.0 (51.1)	7.2 (40.9)	5.8 (32.9)
Type II - all others (including floor-joist type; solid web)	5.2 (29.5)	4.2 (23.8)	4.2 (23.8)
NECH Table 3.3.1. B - Fenestration	**Minimum Energy Rating** (W/m²)		
Windows and sliding glass doors within the scope of CSA Standard A440.2 Operable and fixed glazing with sash Fixed glazing without sash	 -10 0	 -13 -3	 -13 -3
	Maximum Overall Heat Transmittance (W/m² . °C)		
Windows and sliding glass doors outside the scope of CSA Standard A440.2	2.4	2.6	2.6
NECH Table 3.3.2.A. - Building Assemblies in Contact with the Ground	**Minimum Effective Added Thermal Resistance** m².°C/W (ft².°F.h/BTU)		
Walls	4.8 (27.3) @ full surface	3.3 (18.7) @ full surface	1.9 (10.8) @ full surface
Floors-on-Ground Type I - with imbedded heating ducts, cables or pipes (e.g. radiant heating slabs) Type II - all other floors-on-ground (e.g. concrete slab with rigid insulation)	 1.76 (10.0) @ full surface 1.41 (8.0) @ full surface	 1.76 (10.0) @ full surface 1.41 (8.0) @ full surface	 1.76 (10.0) @ full surface 1.41 (8.0) @ full surface
NECH Table 5.3.1.A - Heat Recovery			
Heat recovery on principal exhaust portion of the mechanical ventilation system in dwelling units	required	required	not required
Column 1	2	3	4

Table 2.3
NECH Insulation Requirements - Ontario Zone B Houses

NECH Table 2.2.3.A. - Energy Source Adjustment Factors						
Principal Heating Source	Electricity	Propane	Oil	Natural Gas	Heat Pump Electric	Other
Energy Source Adjustment Factor	1	0.4	0.4	0.24	0.5 (as)* 0.33 (gs)*	1
Column 1	2	3	4	5	6	7

* (as) - air source heat pump; (gs) - ground source heat pump

Table of Prescriptive Requirements	**PRINCIPAL HEATING SOURCE**		
	Electricity, Other	Oil, Propane, Heat Pump (as)	Natural Gas Heat Pump (gs)
NECH Table 3.3.1.A. - Above Ground Building Assemblies	**Minimum Effective Thermal Resistance** ($m^2 \cdot °C/W$)		
Roofs Type I - attic-type	10.8 (61.3)	9.0 (51.1)	7.2 (40.9)
Type II - all others (e.g. roof-joist)	7.1 (40.3)	3.3 (18.7)	3.3 (18.7)
Walls	4.7 (26.7)	4.1 (23.3)	3.3 (18.7)
Floors Type I - truss-type (open web)	10.8 (61.3)	9.0 (51.1)	7.2 (40.9)
Type II - all others (including floor-joist type; solid web)	7.1 (40.3)	4.2 (23.8)	4.2 (23.8)
NECH Table 3.3.1. B - Fenestration	**Minimum Energy Rating** (W/m^2)		
Windows and sliding glass doors within the scope of CSA Standard A440.2 Operable and fixed glazing with sash Fixed glazing without sash	-10 0	-13 -3	-13 -3
	Maximum Overall Heat Transmittance ($W/m^2 \cdot °C$)		
Windows and sliding glass doors outside the scope of CSA Standard A440.2	2.4	2.6	2.6
NECH Table 3.3.2.A. - Building Assemblies in Contact with the Ground	**Minimum Effective Added Thermal Resistance** ($m^2 \cdot °C/W$)		
Walls	5.3 (30.1) @ full surface	3.3 (18.7) @ full surface	1.9 (10.8) @ full surface
Floors-on-Ground Type I - with imbedded heating ducts, cables or pipes (e.g. radiant heating slabs) Type II - all other floors-on-ground (e.g. concrete slab with rigid insulation)	1.76 (10.0) @ full surface 1.41 (8.0) @ full surface	1.76 (10.0) @ full surface 1.41(8.0) @ full surface	1.76 (10.0) @ full surface 1.41 (8.0) @ full surface
NECH Table 5.3.1.A - Heat Recovery			
Heat recovery on principal exhaust portion of the mechanical ventilation system in dwelling units	required	required	required
Column 1	2	3	4

Table 2.4
OBC Insulation Requirements

Minimum Thermal Resistance of Insulation to be Installed Based on Degree Day Zones[1]
OBC Table 9.25.2.A.

Building Element Exposed to the Exterior or to Unheated Space	RSI (R) Value Required		
	Zone 1 Less than 5000	Zone 2 5000 or more	*Electric Space Heating* Zone 1 & 2
Ceiling below *attic or roof space*	5.4 (R 31)	6.7 (R 38)	7.0 (R 40)
Roof assembly without *attic or roof space*	3.52 (R 20)	3.52 (R 20)	3.87 (R 22)
Wall other than *foundation* wall	3.25 (R 19)	3.87 (R 22)	4.7 (R 27)
Foundation walls enclosing heated space	2.11 (R 12)	2.11 (R 12)	3.25 (R 19)
Floor, other than slab-on-ground	4.4 (R 25)	4.4 (R 25)	4.4 (R 25)
Slab-on-ground containing pipes or heated ducts	1.76 (R 10)	1.76 (R 10)	1.76 (R 10)
Slab-on-ground not containing pipes or heating ducts	1.41 (R 8)	1.41 (R 8)	1.41 (R 8)
Column 1	2	3	4

Airtightness

The NECH references the OBC with regard to air barrier installation for buildings in Ontario. It also references the NRC/ONHWP publication "*The Details of Air Barriers*" as representing good practise.

The NECH includes a provision permitting building officials to require an airtightness test where the air barrier installation is at variance with Code requirements or where sufficiency of compliance is questioned. The NECH establishes a performance limit for airtightness for all houses that may be invoked at the discretion of the building official.

The NECH specifies a limit for normalised leakage area (NLA) for the house envelope of 2.0 cm^2/m^2. By comparison R-2000 Program limits the NLA to 0.7 cm^2/m^2 for all Program houses. The NECH requirement is roughly three times looser than the R-2000 requirement. The commentary to the NECH notes that 80% of the houses tested in the survey of 200 houses[1] would pass the 2.0 cm^2/m^2 test.

The Energy Code refers to provincial codes for airtightness requirements for windows and sliding glass doors. In the absence of provincial codes the A2 tightness level of the CSA A440 standard applies.

The OBC requires windows to conform to the A1 tightness level of the CSA A440 standard. It also requires that all exterior windows not have an air infiltration in excess of 0.775 dm^3/s for each metre (0.5 cfm for each foot) of sash crack at a pressure of 75 Pa (0.011 psi) when tested according to ASTM E283 *Standard Method of Test Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors.* For sliding patio doors the OBC requires the door leakage not to exceed $38x10^{-4}$ $m^3/s/m^2$ (0.0125 $ft^3/s/ft^2$) of door area when tested in conformance to ASTM E283. Table 2.5 provides a summary of both the NECH and the OBC requirements for window and door airtightness. The table also provides values for typical exterior doors and windows.

[1] Ventilation and Airtightness in New Detached Canadian Housing, T. Hamlin, J.Forman, M.Lubun, CMHC, 1990

Exterior door assemblies are expected to be designed to limit air leakage in both the NECH and the OBC. Exterior door assemblies must leak less than 2.54 L/s/m^2 of door area based on the ASTM Standard E 283 *Standard Test Method for Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors.* It is unclear whether in-situ performance assessment would be required. The alternative to the above test is that all doors be weatherstripped and equipped with a storm door or with an unheated vestibule.

Table 2.5
Door and Window Airtightness Requirements

Door Type	OBC Requirement	NECH Requirement
Exterior Swing	$11.6x10^{-4}$ m^3/s/m crack, (7.07L/s*)	2.54 L/s/m^2 of door area, (4.96 L/s*)
Sliding Patio Doors	$38x10^{-4}$/m^3/s/m^2 door area, (7.41 L/s**)	A2 level of CAN/CSA-A440***, (4.47 L/s **)
Windows	A1 level of CAN/CSA-A440*** and 0.775 dm^3/s/m of crack sash	A2 level of CAN/CSA-A440***

* leakage rate for a 3'x7' (0.91m x 2.14m) door
** leakage rate for a 6'x6'8" (1.8m x 2.03m) door
*** A1: 2.79 m^3/h/m of sash crack; A2: 1.65 m^3/h/m of sash crack

For insulated steel doors the NECH references the air leakage requirements CAN/CGSB B82.5 "Insulated Steel Doors". The OBC has a similar requirement for these doors although the air leakage requirements of the standard are not specifically referenced.

All fireplace openings must be equipped with tight-fitting doors or enclosures according to the NECH. It does not however contain any definition of what constitutes *tight-fitting.*

Both the OBC and the NECH require all attic hatches to be weatherstripped.

Trade-offs and Performance Compliance

The NECH allows trade-off compliance based on an analysis of component areas and effective (or added) thermal resistance. Trade-off calculations for the NECH are based on calculation of interior envelope areas and effective R-values. A reduction in the effective thermal resistance of one component may be compensated by increasing the effective thermal resistance of another. Key is not increasing the total heat loss, summed across all envelope components, beyond that established by the prescriptive insulation levels.

Trade-offs and performance compliance permits a reduction of 20% in the R-values of walls and joist floors and a 40% reduction for all other opaque envelope components. For fenestration the transmission losses must not be greater than 167% of the prescriptive requirements.

Section 9.38 Thermal Design of the OBC can be used as an alternative to Section 9.25. Thermal Design allows limited trade-offs across envelope components. The Section requires some updating but appears similar in intent to the trade-off provisions of the NECH. Section 9.38 does not describe methods for measuring trade-offs and compliance.

The NECH permits trade-offs across any number of envelope components by using performance path, using a computer simulation program for the entire building's heat loss. The OBC provides no similar provision.

Lighting

The NECH requires all individual dwellings be equipped with a photocell and a timer or motion detector on exterior lights. There is no similar requirement as part of the OBC. Exterior lighting controls are required for individual dwelling units. The NECH requires all exterior lighting to be equipped with a photocell and timer or a motion detector.

There are no requirements for energy efficient lighting in either the OBC or the NECH.

NECH Appendix Note: High Efficacy Interior Lighting
Research Indicates that the installation of high efficiency (non-incandescent) lighting in dwellings is cost effective and should be encouraged. High Efficacy fixtures and lamps are available which provide high quality lighting. The capital cost of these units, however, is higher than that of commonly installed incandescent units, and discourages their installation. Evidence indicates that if high efficacy units are required by the Code, low cost units would probably be installed initially, only to be replaced at a later date by low cost, low efficacy fixtures which provide better lighting quality. Until this implementation and enforcement issue can be resolved, a requirement for high efficacy lighting cannot be expected to be effective.

Spaces Considered: *High efficacy lighting was considered for kitchens, bathrooms, water-closet rooms, laundry rooms, garages and halls. Storage spaces and work shops were also considered as spaces which might be lit with high efficacy luminaries but, although quality of light may not be an issue, life cycle cost may not warrant installation.*

ASHRAE *requirement for 25 lumens per Watt was derived from the California Code without consideration of viability or quality of light. The California Code, which requires 40 L/W, does not appear to be working. It is not accepted by either the industry or the consumer because it is easy to get around, not enforceable or effective. (The fixture is simply replaced after inspection).*

Objectives provided are:

- *High efficacy lamps do not translate into quality or amount of illumination. For example a 18 L/W halogen lamp can outperform a 40 L/W fluorescent which consumes the same power. The characteristics of the fixture are critical to lighting performance.*
- *Builders install cheap and mean fixtures to meet code. These often provide inadequate light leaving dissatisfied customers who then blame the Code.*
- *New high efficacy products have medium screw bases. Efficacy requirements can be met with these but they can easily be replaced by incandescent lamps.*

Solutions/Options: *There is no simple answer to the issue. The installation of an occupancy sensor provides an option to installation of high efficacy luminaries.*

Heating, Ventilating and Air Conditioning Systems

Air Distribution Systems

The NECH requires air distribution systems for houses to incorporate a means of adjusting the flow in each supply duct with the intention that balancing of the system be possible. Article 5.2.9.3. extends theses provisions requiring the ability to reduce the delivered heat to all rooms in the dwelling on an individual basis. Automatic devices, or manual dampers, valves or switches can be used to control the heat to each room. It is unclear in the case of dampers in forced air duct branches whether they would need to remain accessible at all times. Part 6 of the Ontario Building Code contains a similar provision although the primary intention of the OBC provision appears to provide for supply duct balancing at time of system installation.

Pipes, ducts or plenums which run outside must be insulated according to the NECH. Outside ducts with the exception of factory-installed plenum or ducts must be insulated to the same levels required of exterior walls. Part 6 of the OBC contains similar provisions.

According to the NECH, ducts for exhaust fans that are not intended to operate on a continuous basis must be equipped with backdraft or motorized dampers. All air intakes must be equipped with motorized dampers with the exception of combustion air intakes.

Temperature and Humidity Controls

A programmable thermostat is required by the NECH for all dwelling units that has a range from 13 °C to 29 °C. A 1.5 °C deadband is also required for all thermostats. Heating and cooling must be controlled independently. When individual electric heaters are used, the house must be zoned and the heaters sized for each zone. Heaters for all rooms greater than 3 m^2 in floor area (except vestibules) must be controlled separately.

The NECH includes provisions for controls for humidifiers where they are installed. Humidifiers must be capable of being turned down to 30% relative humidity.

Heat Pump Controls

Heat pumps equipped with back-up heaters are required to be equipped with controls to prevent back-up heater operation when the heating load can be met by the heat pump alone (except during defrost cycles). Heat pumps must also be equipped with setback controls that provide temporary suppression of back-up heat or adaptive anticipation of the recovery point in order to prevent the unit form resorting to supplementary at the time of back-up.

NECH APPENDIX NOTE:
Several techniques of achieving this exist:
- *separate exterior temperature sensor,*
- *gradual raising of the control point,*
- *controls that learn when to start recovery from previous experience.*

Equipment Efficiency

The NECH references provincial energy efficiency acts for heating, ventilating and air conditioning equipment.

NECH APPENDIX NOTE:
The National Building Code of Canada includes detailed requirements for the mechanical ventilation of dwelling units. However, as the NBC is concerned only with health and safety issues, those requirements address only the effectiveness of ventilation systems not their efficiency, which is left to this Code. Therefore the requirements of this Code should be read in conjunction with those of the NBC. For example, the requirements in NBC Subsection 9.32.3 Mechanical Ventilation, can be satisfied using a heat recovery ventilator but can also be satisfied using other types of ventilation equipment. In cases where this Code requires heat recovery from the exhaust portion of the ventilation system, a heat recovery ventilator would probably become the system of choice.

The NECH requires the principal exhaust portion of the mechanical ventilation system be equipped with heat recovery. Heat recovery ventilator minimum efficiency specified is 65% at 0°C, 55% at -25°C and 45% at -40°C.

Service Water Heating Systems

The NECH requires storage water heaters to be equipped with heat traps for all water heaters. Insulation (at least 12 mm (1/2")) over the first 2 m (6'7") of hot water pipe must also be provided. The system must have an automatic temperature control and if larger than 100 L, it must have a shut-off device.

Low flow shower heads with a maximum permitted flow of 9.5 L/min. are required as part of the NECH and the OBC. The Energy Code also contains provision for heated indoor and outdoor swimming pools.

Electric Power

The NECH requires all houses to be individually metered. This does not require individual billing but rather only individual submetering. Where exterior outlets are provided at least one should be on a switch or a timer (to accommodate decorative lights). Where outlets are also provided for vehicle block heaters, the outlets must also be controlled by a switch or a timer. The Ontario Building Code contains no specific similar requirement.

NECH Economic Assumptions

Capital Costs

Energy Building Group developed a construction cost database for opaque envelope assemblies used in the NECH life cycle cost analyses. Enermodal Engineering developed a similar cost data for fenestration assemblies. Each database featured distinct sets of assemblies and costs for buildings and for houses.

All construction costs developed represented home buyer costs while all fenestration assembly costs were costs to the builder. To convert builder costs into home buyer costs for the fenestration assemblies, the appropriate builder markups for overheads and profit margins were added, as well as applicable Ontario taxes.

The markups and taxes for all building materials, including fenestration products are shown below in Table 2.6.

Table 2.6
NECH Mark-up on Building Products

Item	Mark-up
Builder General Profit	20%
Ontario Sales Tax	8%
GST	4.48%
Total	32.48%

Energy Prices and Other Economic Assumptions

Table 2.7 identifies all of the economic assumption used in the NECH analysis including all energy price forecasts.

Table 2.7
NECH Economic and Administrative Assumptions for Ontario

General Economic Parameters			
Year of Analysis	1993		
General Inflation Rate	3.00		
Real Discount Rate (netted for inflation)	6.00		
Nominal Interest Rate	9.00		
Economic Life (yr)	30.0		
Environmental Multiplier	1.00		
Fuel Related Parameters			
Applicable Taxes	7% GST		
Energy Prices	Electricity ($/kWh)	Gas ($/m^3)	Oil ($/L)
As quoted	0.0844	0.2104	0.3651
With taxes	0.0903	0.2251	0.3907
Energy Cost ($/GJ)	$25.09	$5.94	$10.10
Energy Source Adjustment Factor	1.00	0.24	0.40
Real Fuel Escalation Rate (netted for inflation)	0.40	1.40	1.20
Nominal Fuel Escalation Rate	3.40	4.40	4.20
Effective Interest Rate	5.42	4.41	4.61
Present Worth Factor	14.7	16.5	16.1

3. Capital and Annual Operating Cost Analysis

Capital and operating cost analysis was performed to provide data for comparison of first costs, and subsequently life cycle costs and environmental impacts analyzed later in this study.

In this study, a hybrid approach to capital cost analysis was adopted to accommodate the methodologies used to obtain the requirements found in the OBC, as well as in the NECH. Without this accommodation, it would not be possible to provide a fair comparison between the requirements of these two codes. The following two sections briefly review each of these code's methodologies.

Ontario Building Code Methodology And Assumptions

In the case of the capital cost analysis for the OBC requirements, it was based on the incremental costs associated with the minimum thermal requirements in the previous version of the Code (1990). Incremental costs were obtained for the building envelope, space heating systems, domestic water heating systems, and mechanical ventilation systems. A quantity survey of the incremental capital costs was performed, and then reconciled by conducting a builders' roundtable representative of small and large builders from various parts of Ontario. Adjustments in capital costs associated with various sizes of houses (a total of 6 benchmark houses were employed) were also included. The interactive impacts of thicker wall assemblies on basement foundation wall thickness were also quantified, along with the cost of jamb extensions around windows. The cost of callbacks due to basement leakage were also factored into the cost of full height basement insulation. These builder costs were then converted into selling prices by applying a 30% mark-up (including PST) along with a net 4.5% GST.

Operating costs were simulated using HOT-2000 Version 6.02 in two locations: Toronto and Sault Ste Marie, corresponding to Zones 1 and 2, respectively, in the OBC. A full range of fuel types, appliance types and efficiencies were simulated to arrive at the annual energy consumption. This consumption was subsequently converted into an annual operating cost.

For a more complete description of this approach, refer to *Energy Impact and Cost Effectiveness of Energy Efficiency Improvements for Housing in Ontario*, prepared by Habitechnica for the Ontario Ministry of Energy, June 1991.

National Energy Code For Housing Methodology And Assumptions

Capital cost analyses were performed separately for opaque residential building envelope components, mechanical ventilation systems and windows.

In the case of opaque separators, a quantity survey approach was used exclusively to arrive at the capital cost of assemblies - no reconciliation with builders was conducted for regional or scale factors. Rather than using an incremental cost approach, a wide array of complete building assemblies was costed absolutely on an area basis, including all applicable mark-ups and taxes (20% builder mark-up, 8% PST and 4.5% net GST). Adjustments to unit prices within an assembly were performed to account for increases in assembly thickness (e.g., the additional cost of jamb extensions in exterior walls thicker than 98 mm). However, adjustments to prices between assemblies were not performed. For instance, in the case of exterior walls, since aluminum siding was used exclusively, the cost of a thicker foundation wall to support brick veneer (a common and popular finish in Ontario) over thicker exterior wall assemblies, was not factored.

For more information on the capital costing of opaque separators, refer to *A Construction Methodology for the Building Envelope: Final Report*, February 21, 1992 prepared under NRC Contract 991-901 by Energy Building Group Ltd., and *Development of a Database of Construction Costs of Opaque Envelope Components for Use in the Development of the Energy Code: Residential Construction Final Report*, March 31, 1993 by Energy Building Group Ltd.

Of all mechanical systems in the dwelling, only mechanical ventilation systems were costed, and the breakdown of costing appears in the latter publication noted above. The specific means by which capital costs were estimated are not provided in this document. Two options were examined: a balanced system consisting of exhaust fans and an outdoor air supply connected to, and interlocked with, the forced air heating system; and a 60% efficient HRV connected to the return air plenum of the forced air furnace. An average airflow of 30 L/s (60 cfm) was used to determine the ventilation heat load for both systems.

It should be noted that since the objective of the NECH was not to examine differences between fuel types and/or system types for any comparative purposes, the capital costs of space and domestic water heating equipment were not considered.

Window capital costs were derived by conducting a survey of manufacturers' and component suppliers' retail prices, and builders' price discounts and mark-ups, to obtain a capital cost per unit area. A typical vinyl casement (600 mm x 1220 mm) and fixed glazing unit (1220 mm x 1220 mm) were surveyed. The lowest cost per unit area within an ER category was used as the capital cost of windows. For more detailed information, refer to *Cost and Performance of Canadian Windows*, prepared for the National Research Council of Canada by Enermodal Engineering Limited, revised May 1993.

Operating costs were simulated using HOT-2000 in two degree-day locations: Zone A and Zone B, corresponding to Zones 1 and 2, respectively, in the OBC. A typical two-storey, 160 m^2 (1,720 ft^2) house, with full basement, 20% glazing to floor area ratio (30% obstruction of south facing glazing), and a volume of 604 m^2 (21,300 ft^3) was modelled. Effective thermal resistance values of assemblies, accounting for thermal bridging, were employed in the analyses. The annual heat loss was then converted into an annual heat loss per unit area of assembly, in the case of opaque separators and windows. Electricity, oil, propane and natural gas fuel types were analyzed assuming 80% efficiency for combustion appliances, 100% efficiency for electrical resistance appliances, and a COP of 2.0 for air-source heat pumps; 3.0 for ground source heat pumps (refer to the discussion in Chapter 6). These efficiencies, and their corresponding fuel prices, were applied to the annual heat loss per unit area to obtain the unitary annual operating costs. The unit based capital costs and annual operating costs were used later as input data to the lifecycle cost analyses.

Methodology And Assumptions Used In This Study

The methodology used in this study is based essentially on that established in the previous energy profiles study conducted in Ontario (see *Energy Impact and Cost Effectiveness of Energy Efficiency Improvements for Housing in Ontario*, prepared by Habitechnica for the Ontario Ministry of Energy, June 1991). Aspects of the NECH methodology, particularly with respect to effective thermal resistance values and unit capital costs, were adopted. Deviations from either of these two approaches have been identified below.

An overview of the methodology prior to dealing with each of its aspects in depth indicates the essential process. Using 6 benchmark houses, the effective thermal resistance values of assemblies required under the OBC and the NECH were approximated using those corresponding to actual assemblies. Requirements dependent on climatic zone and fuel type were reflected accordingly in the building envelope, space heating and mechanical ventilation systems. The NECH costing data corresponding to these assemblies was applied to arrive at the capital cost for each variation of benchmark house envelope. Data from the most recent Ontario study (1994 *Ontario Housing Energy Profiles* prepared by Habitechnica for Ontario Hydro, May 1994) was used to cost space heating and mechanical ventilation systems.

A HOT-2000 model consisting of the building envelope, space heating and mechanical ventilation systems was used to simulate the annual energy demand and consumption of each resulting variation of benchmark house. The annual energy consumption by fuel type was then multiplied by the 1994 Ontario retail pricing for energy to calculate the annual operating cost for each variation of benchmark house.

Benchmark Houses

The benchmark houses used in this study are the same as those found in previous Ontario energy profiles studies, with the exception of an additional benchmark house - a 1,320 ft^2 (123 m^2) bungalow. In total, 6 benchmark houses were analyzed: a 2,100 ft^2 (196 m^2) two-storey; a 1,320 ft^2 (123 m^2) two-storey; a 1,320 ft^2 (123 m^2) bungalow; a 1,070 ft^2 (137m^2) semi-detached; a 1,080 ft^2 (100 m^2) row house end unit; and a 1,080 ft^2 (100 m^2) row house inside unit. Refer to Appendix II for the plans and elevations, as well as the physical characteristics of these benchmark houses.

Using benchmark house types with physical characteristics corresponding to those of typical housing starts has several advantages. First, it is possible to determine if Code requirements are appropriate and equitable over all house types. Second, the simulation data may be correlated with housing start forecasts to provide estimates of capital costs and energy consumption over the new home population.

These 6 benchmark houses and their respective physical characteristics were employed to calculate the capital costs of the building envelope, space heating and mechanical ventilation systems, and to simulate annual energy demand and consumption.

Effective Thermal Resistance of Assemblies

The effective thermal resistance of actual assemblies was used to simulate annual energy demand and consumption. This marks a departure from previous studies where nominal insulation levels corresponding to minimum Code requirements were employed.

Actual assemblies were used to determine effective thermal resistance levels which most closely approximated minimum requirements in both Codes. The minimum requirements in the Codes are intended to permit a broad range of products to be used in construction. These levels are not necessarily achievable in practice when constructing assemblies using commonly available materials. Since the NECH background studies had arrived at the effective thermal resistance and capital costs of actual assemblies, these were employed directly, or slightly adapted, to perform more realistic analyses. This accounts for the many cases where effective thermal resistance levels exceed minimum levels required by the Codes.

It should be noted that since the first release of the NECH for review and comment, the maximum level of thermal insulation in below grade walls has been reduced to an effective level of RSI 3.3 (R-18.7). Concerns over the loss of interior space were cited by staff as the reason for this change. RSI 3.4 (R-19.2) was used within the simulations as the effective value reflecting the common construction practise used in Ontario. It should also be noted that the thermal resistance values that were used were those of version 1.0 of the NECH with the below grade walls as the only exception. The simulations do not reflect subsequent changes to the NECH.

In the case of the OBC, when ground source heat pumps were used to deliver space heating, the thermal resistance of building assemblies was set to the same level as required for electric resistance heated dwellings. This approach is consistent with previous studies, and recognizes that in reality, back-up resistance heating may account for a significant proportion of the annual space heating energy consumption. This is particularly the case when setback thermostats are used, and/or the sizing of the heat pump is closely matched to the design heat loss. Since NECH requirements are virtually identical to those under the OBC, results for NECH ground source heat pump simulations also represent current OBC practices.

Window performance was modelled according to performance levels cited in the NECH background studies. Again, actual windows perform differently than the minimum levels prescribed in the OBC.

Tables 3.1 to 3.10 summarize the nominal and effective thermal resistance values used in the HOT-2000 simulations. Again, it is important to note that these may not always reflect the minimum levels required under the two Codes.

Table 3.1
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Electrically Heated Dwellings

ONTARIO - Less than 5000 DD		
COMPONENT	OBC ZONE 1	NECH ZONE A
Ceiling	7.0(R-40)/*7.2(R-40.9)*	8.8(R-50)/*9.0(R-51.1)*
Walls	4.7(R-27)/*4.4(25.2)*	4.7(R-27)/*4.4(R-25.2)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	3.25(R-19)/*3.4(R-19.2)*
Windows*	-13**/*0.50(R-2.8)*	-10***/*0.53(R-3.0)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
***Nominal ER -10 translates into DG low-e argon, actual ER -9.5, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.2
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Oil/Propane Heated Dwellings

ONTARIO - Less than 5000 DD		
COMPONENT	OBC ZONE 1	NECH ZONE A
Ceiling	5.4(R-31)/*5.8(R-33.1)*†	7.0(R-40)/*7.2(R-40.9)*
Walls	3.25(R-19)/*3.1(R-17.4)*	3.25(R-19)/*3.1(R-17.4)*
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	3.5(R-20)/*3.4(R-19.2)*
Windows*	-25**/*0.39(R-2.2)*	-13***/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, actual ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.3
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Air Source Heat Pump Heated Dwellings

ONTARIO - Less than 5000 DD		
COMPONENT	OBC ZONE 1	NECH ZONE A
Ceiling	7.0(R-40)/*7.2(R-40.9)*	7.0(R-40)/*7.2(R-40.9)*
Walls	4.7(R-27)/*4.4(25.2)*	3.25(R-19)/*3.1(R-17.4)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	3.5(R-20)/*3.4(R-19.2)*
Windows*	-13**/*0.50(R-2.8)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.4
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Ground Source Heat Pump Heated Dwellings

ONTARIO - Less than 5000 DD		
COMPONENT	OBC ZONE 1	NECH ZONE A
Ceiling	7.0(R-40)/*7.2(R-40.9)*	5.6(R-32)/*5.8(R-33.1)*
Walls	4.7(R-27)/*4.4(25.2)*	3.0(R-17)/*3.0(R-16.9)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	2.1(R-12)/*1.9(R-10.8)*
Windows*	-13**/*0.50(R-2.8)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.5
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Natural Gas Heated Dwellings

ONTARIO - Less than 5000 DD		
COMPONENT	OBC ZONE 1	NECH ZONE A
Ceiling	5.4(R-31)/*5.8(R-33.1)*†	5.6(R-32)/*5.8(R-33.1)*
Walls	3.25(R-19)/*3.1(R-17.4)*	3.0(R-17)/*3.0(R-16.9)*
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	2.1(R-12)/*1.9(R-10.8)*
Windows*	-25**/*0.39(R-2.2)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, actual ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.6
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Electrically Heated Dwellings

ONTARIO - 5000 DD or Greater		
COMPONENT	OBC ZONE 2	NECH ZONE B
Ceiling	7.0(R-40)/*7.2(R-40.9)*	10.6(R-60)/*10.9 (R-61.6)*
Walls	4.7(R-27)/*4.4(25.2)*	5.1(R-29)/*4.7(R-26.7)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	3.25(R-19)/*3.4(R-19.2)*
Windows*	-13**/*0.50(R-2.8)*	-10***/*0.53(R-3.0)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
***Nominal ER -10 translates into DG low-e argon, actual ER -9.5, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.7
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Oil/Propane Heated Dwellings

ONTARIO - 5000 DD and Greater		
COMPONENT	OBC ZONE 2	NECH ZONE B
Ceiling	6.7(R-38)/*6.9(R-39.4)*	8.8(R-50)/*9.0(R-51.1)*
Walls	3.87(R-22)/*4.0(R-22.5)*†	4.6(R-26)/*4.2(R-23.6)*
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	3.5(R-20)/*3.4(R-19.2)*
Windows*	-25**/*0.39(R-2.2)*	-13***/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, actual ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.8
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Air Source Heat Pump Heated Dwellings

ONTARIO - 5000 DD and Greater		
COMPONENT	OBC ZONE 2	NECH ZONE B
Ceiling	7.0(R-40)/*7.2(R-40.9)*	8.8(R-50)/*9.0(R-51.1)*
Walls	4.7(R-27)/*4.4(25.2)*	4.6(R-26)/*4.2(R-23.6)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	3.5(R-20)/*3.4(R-19.2)*
Windows*	-13**/*0.50(R-2.8)*	-13***/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.9
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Ground Source Heat Pump Heated Dwellings

ONTARIO - 5000 DD and Greater		
COMPONENT	OBC ZONE 2	NECH ZONE B
Ceiling	7.0(R-40)/*7.2(R-40.9)*	7.0(R-40)/*7.2(R-40.9)*
Walls	4.7(R-27)/*4.4(25.2)*	3.4(R-19.5)/3.4*(R-19.5)*
Foundation Walls	3.25(R-19)/*3.4(R-19.2)*†	2.1(R-12)/*1.9(R-10.8)*
Windows*	-13**/*0.50(R-2.8)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Table 3.10
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Natural Gas Heated Dwellings

ONTARIO - 5000 DD and Greater		
COMPONENT	OBC ZONE 2	NECH ZONE B
Ceiling	6.7(R-38)/*6.9(R-39.4)*	7.0(R-40)/*7.2(R-40.9)*
Walls	3.87(R-22)/*4.0(R-22.5)*†	3.4(R-19.5)/*3.4(R-19.5)*
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	2.1(R-12)/*1.9(R-10.8)*
Windows*	-25**/*0.39(R-2.2)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, actual ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, actual ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

Mechanical Equipment Efficiencies

The seasonal efficiencies of space heating equipment used in the simulations have been summarized in Table 3.11.

Table 3.11
Space Heating Systems Used for Benchmark House Energy Simulations

ONTARIO - Zones 1 & 2 (A & B)		
Principal Heating Source	System Description	Seasonal Efficiency*/COP
Electricity	Forced Air Furnace	100%
Oil	Forced Air Furnace	78%
Propane	Forced Air Furnace	78%
A/S Heat Pump	Forced Air System, Electric Resistance Back-Up	200%/2.0
G/S Heat Pump	Forced Air System, Electric Resistance Back-Up	300%/3.0
Natural Gas	Induced Draft Forced Air Furnace	78%
Natural Gas	Condensing Forced Air Furnace	90%

* In some cases the standards under which these are measured do not properly account for co-heating from fan blowers.

It should be noted that in the case of heat pump technologies, a much higher reference COP with no use of back-up resistance heating is required to achieve the seasonal COPs noted above. Actual COPs as measured in the field should be

used to verify values used in the simulations.
Mechanical ventilation system options examined in the study are summarized in Table 3.12. It should be noted that the requirements for heat recovery under the OBC are not differentiated by climatic zone, as in the NECH.

Table 3.12
Ventilation Systems Used for Benchmark House Energy Simulations

ONTARIO - Zone 1 (A) and Zone 2 (B)			
Principal Heating Source	OBC Zones 1 & 2	NECH Zone A	NECH Zone B
Electricity	HRV	HRV	HRV
Oil, Propane	Fan(s)	HRV	HRV
A/S Heat Pump	HRV	HRV	HRV
G/S Heat Pump	HRV	Fan(s)	HRV
Natural Gas	Fan(s)	Fan(s)	HRV

HRV's modelled with 60% seasonal effectiveness, 125 Watts.
Exhaust Fan(s) modelled as 125 Watts.
Mechanical ventilation assumed continuous at 30 L/s (60cfm).

The actual amount of time a mechanical ventilation system operates is critical to the determination of its cost effectiveness. It has been assumed that mechanical ventilation at the specified rate is provided 24 hours a day throughout the heating season. This assumption requires validation through the field monitoring of actual dwellings.

Capital Costs

A number of building envelopes, space heating and mechanical ventilation combinations were analyzed in each of the benchmark houses. Beginning with building envelopes, two types of envelope were analyzed - Ontario Building Code (OBC) minimum requirements (as of 1993) and 1995 proposed NECH levels. Tables 3.13 to 3.16 provide descriptions of envelope assemblies and associated costs.

Table 3.13
Costs of Foundation Wall Assemblies

Description	Effective Thermal Resistance	Cost $\$/m^2$
RSI 2.11(R-12) Batt	RSI 1.9 (R-10.8)	93.32
RSI 3.25(R-19) Batt	RSI 3.4 (R-19.2)†	98.30
RSI 4.9(R-28) Batt	RSI 4.8 (R-27.3)	101.53
RSI 5.4(R-32) Batt	RSI 5.3 (R-30.1)	102.52

†Effective thermal resistance value reflects common practice in Ontario.

Table 3.14
Costs of Exterior Wall Assemblies

Description	Effective Thermal Resistance	Cost $/m²
RSI 3.0(R-17) 2x4 + 1" XTPS II	RSI 3.0 (R-16.9)	78.11
RSI 3.25(R-19) 2x6	RSI 3.1(R-17.4)	78.68
RSI 3.4(R-19.5) 2x4 + 1-1/2" XTPS II	RSI 3.4 (R-19.5)	82.15
RSI 3.87(R-22)† 2x6 + 1" XTPS II	RSI 4.0 (R-22.5)	86.28
RSI 4.6(R-26) 2x6 + 1-1/2" EPS II	RSI 4.2 (R-23.6)	87.09
RSI 4.7(R-27) 2x6 + 1-1/2" XTPS II	RSI 4.4 (25.2)	90.31
RSI 5.1(R-29) 2x6 + 1-1/2" Phenolic	RSI 4.7 (R-26.7)	92.03

† Nominal thermal resistance denotes OBC minimum requirement. Assembly description and effective thermal resistance value reflect common practice in Ontario.

Table 3.15
Costs of Window Assemblies

Description	Effective Thermal Resistance	Cost $/m²
DG	RSI 0.39 (R-2.2)	231.84
DG low-e	RSI 0.50 (R2.8)	247.74
DG low-e argon	RSI 0.53 (R-3.0)	264.96

Table 3.16
Costs of Attic Type Ceiling Assemblies

Description	Effective Thermal Resistance	Cost $/m²
RSI 6 (R-32) BLOWN	RSI 5.8 (R-33.1)	59.27
RSI 6.7 (R-38) BLOWN†	RSI 6.9 (R-39.4)†	60.86
RSI 7.0 (R-40) BLOWN	RSI 7.2 (R-40.9)	61.29
RSI 8.8 (R-50) BLOWN	RSI 9.0 (R-51.1)	63.90
RSI 10.6 (R-60) BLOWN	RSI 10.9 (R-61.6)	66.49

† Effective thermal resistance and cost interpolated from NECH data.

The capital costs of the benchmark house envelopes derived from the applicable unit costs from the previous tables are summarized in Appendix II under *Envelope Capital Costs.*

Mechanical equipment capital costs were based on prices reported during the 1991 Builder Roundtable associated with the 1991 Ontario energy profiles study cited earlier. In the spring of 1994, some of these builders were contacted to update prices. The builders all reported that mechanical equipment prices have remained virtually flat since 1991. It appears that slight increases in equipment and materials have been countered by similar decreases in labour due to dwindling construction activity levels. HRVs have dropped slightly in price since 1991, however, the Part 9 ventilation system has gone up in price over a simple exhaust-only ventilation system due to 2-speed furnace fans and interlocking switches. This information was used to modify 1991 mechanical equipment capital costs accordingly. Due to the adjustments in costs reflecting house size and layout, a simplified table of capital costs for mechanical equipment is not possible. Refer to *Mechanical Systems Capital Costs* in Appendix II for specific data. In all cases, capital costs represent installed mechanical equipment and envelope upgrades, including builder mark-up for profit, and all applicable taxes. Refer to *Capital Cost Summaries* in Appendix II of this report.

Energy Pricing

The energy prices used to determine annual operating costs in this study differ slightly from those used in the NECH analyses. 1994 retail prices were obtained from Ontario utilities in the case of electricity and natural gas, and from the Ontario Ministry of Environment and Energy in the case of propane and oil. A comparison of the prices may be found in Table 3.17 below.

Table 3.17
1994 Retail Energy Pricing

ENERGY (FUEL)	1994 RETAIL PRICE*	1994 ¢/MJ
Electricity	9.03 ¢/kWh	2.51
Natural Gas	5.94 $/GJ	0.59
Oil	10.1 $/GJ	1.01
Propane	14.08 $/GJ	1.41

* Inclusive of all applicable taxes.

Prior to performing the capital cost analysis, capital costs used in the NECH were validated by comparing these with the costs used in the earlier Ontario energy profiles study.

Capital Cost Validation

Extensive capital cost validation was not possible within the scope of this study. The work performed in Ontario for the OBC requirements was based on incremental costs, whereas the NECH analyses were based on complete assemblies.

This has necessitated a comparison of the incremental cost differences between the assemblies used to derive the OBC requirements, and the corresponding NECH assemblies. The results of this comparison are summarized in Table 3.18 below.

Table 3.18
Comparison of Incremental Costs
NECH 1994 Versus OBC 1991

ITEM	NECH '94	OBC '91	% DIFF. wrt OBC
	$/m²		
Partial to Full Height Basement Insulation (RSI 2.1)	$21.86	$19.18	+14%
2x6 Wall to 2 x 6 Wall with 1" XTPS II	$7.61	$8.92	-14.8%
DG to Low-E Glazing	$33.12	$71.59	-53.7%
Ceiling Insulation RSI 5.6 - RSI 10.6	$7.22	$8.30	-13.1%
Above costs include builder mark-up and net applicable taxes.			

In the case of going from a basement with RSI-2.1 (R-12) insulation 2 feet below grade to a basement with RSI-2.1 (R-12) full height insulation, the NECH incremental cost is reported as $\$21.86/m^2$ versus $\$19.18/m^2$, a difference of +14% with respect to the 1991 estimate. This difference is accountable within the levels of annual inflation over this period.

A comparison of incremental costs in going from a 2x6 wall to a 2x6 wall with 1 inch of Type II extruded polystyrene insulation was reported as $\$7.61/m^2$ in the NECH and $\$8.92/m^2$ in the 1991 OBC study, a difference of -14.8%. The OBC study assumed an additional $3m^3$ of concrete for additional wall thickness needed to support brick veneer (the NECH study assumed a siding type exterior finish). The resulting difference is within the levels of annual inflation over this period.

The markedly lower incremental cost reported for Low-E glazing over clear double glazing in the NECH is in keeping with the pricing trends in the window industry. Low-E is far more common today than it was in 1991, and the difference in costs reflects today's costs.

The incremental cost of going from RSI-5.6 to RSI-10.6 ceiling insulation was reported as $\$7.22/m^2$ in the NECH study and $\$8.30/m^2$ in the OBC study. This 13.1% difference is mainly accounted for by the inclusion in the OBC study of the cost of modifying roof trusses to accept this higher level of insulation full depth over the entire ceiling area. This may not normally be done in practice, resulting in eave compression, however the lower effective insulation level of the ceiling would have to be properly taken into consideration.

Given the bases for comparison of incremental costs between the two studies, it may be concluded that the costs used in the NECH study are reasonably similar, and may be used with a comparable level of confidence. Regional variations in price, which were taken into account by different means in the two studies, are reflected using averaged costs. This is a limitation in the capital cost analyses for both studies', particularly in the case of Ontario's two climatic zones, which also reflect significant differences in labour and material prices. The absence of accurate, accessible and up-to-date cost statistics for the homebuilding industry presently requires simplified approaches to costing due to economic constraints.

Simulation Of Annual Energy Demand And Consumption

The simulation of annual energy demand and consumption was carried out using HOT-2000 version 6.02. The performance of each benchmark house, in each of the two degree-day zones, was simulated according to the existing OBC requirements pertaining to the selected fuel type, and the recommended NECH requirements.

The following assumptions were used in the modelling:

1. Effective thermal resistance values for all assemblies were used as per Tables 3.1 to 3.10;
2. Space heating systems were modelled according to Table 3.11;
3. Mechanical ventilation was modelled at 30 L/s (60 cfm) continuously, using the systems described in Table 3.12;
4. Windows were modelled without solar obstruction, since this was not quantifiable within the scope of this study;
5. Allowable temperature swings and occupancy were maintained constant in all runs to avoid discrepancies; and
6. Domestic water heating energy and space cooling energy were not considered.

The peak and annual energy demands of each benchmark house were obtained but not reported in this study, since time of use rates were not considered for any of the fuel types examined. Annual energy consumption is reported in Appendix II under *Annual Energy Consumption*. It should be noted that in the case of fossil fuels, a fraction of the space heating is provided by waste heat from furnace and ventilation fans being released to the indoor space.

In order to provide a basis for comparison of initial costs, a summary of capital and annual operating costs is provided in Appendix II under *Capital and Annual Operating Costs Summary*. The following section provides a discussion of the results obtained.

Discussion Of Results

This discussion of results obtained from the analysis of capital and annual operating costs is primarily intended to identify any significant first costs implications between the requirements of the OBC and the NECH.

Zone 1(A)

Beginning with Zone 1(A), the differences between OBC and NECH requirements for electrically heated dwellings are not significant. Significant differences have been estimated as differences extending beyond the acceptable margin of error in capital costs (plus or minus 5%). In all cases, differences are less than 5% between benchmark houses. This is also virtually the case for air source heat pumps.

Ground source heat pumps vary tremendously depending on whether or not the actual OBC requirements are used in the analysis. The OBC does not consider houses equipped with ground source heat pumps as electric houses. In the results presented in this report, it has been assumed that the same envelope and mechanical ventilation system required for electric resistance heating systems applies to ground source heat pumps. This is consistent with approaches in earlier studies, and to some extent reflects the energy conscious design associated with this choice of heating system. Under this scenario, OBC capital costs range from approximately $1,300 to $3,600 higher than their NECH counterparts, and annual energy consumption ranges from $100 to $150 lower, respectively. If the actual OBC requirements are used, these virtually coincide with the NECH requirements, and hence there is no practical difference between the two. However, from the perspective of the informed consumer, the OBC/NECH dwelling with a ground source heat pump costs approximately $5,000 more than the OBC dwelling with an air source heat pump, and still costs $35 more to operate each year - the cost effectiveness of this technology remains questionable unless the domestic water heating and space cooling benefits are accounted for.

For oil and propane, capital costs are not significantly different between the OBC and the NECH, with the latter's requirements being generally higher priced. However, the savings in annual energy consumption are significant in the case of the NECH. This "bigger bang for the buck" results from improved thermal efficiencies in ceiling insulation, foundation walls, windows and the installation of an HRV. Since main walls are not affected, the cost per relative increment of improved performance is marginally low.

The NECH represents an electric resistance and natural gas hybridization of requirements.

Natural gas heated dwellings under either OBC or NECH requirements perform virtually identically. Both high efficiency and mid-efficiency heating systems were analyzed in order to later determine the appropriateness of the minimum efficiency requirements of the Codes.

From a consumer's perspective, under both Codes' requirements, natural gas represents the most cost effective fuel choice in dwellings and electric resistance heating the least cost effective. However, the gap between the thermal performance of dwellings, built to the various Code requirements based on fuel types, has closed further under the NECH than the OBC, due largely to improved minimum requirements for window performance.

Zone 2(B)

In Zone 2(B), the differences between OBC and NECH requirements for electrically heated dwellings are more significant than in Zone 1(A), ranging from approximately $1,300 more for an NECH large two storey to about $500 more for a row house. In the case of air source heat pumps, the OBC and the NECH requirements are effectively identical.

OBC and NECH requirements for dwellings with ground source heat pumps are similar, with the NECH capital costs being at the most, about $2,000 less than those associated with the OBC requirements, assuming the electric resistance envelope requirements are applied. If the OBC requirements are interpreted as being the same as those for natural gas heating, then the gap in capital and annual operating cost narrows significantly. Again, the cost effectiveness of this technology remains questionable until the domestic water heating and space cooling benefits are quantified.

For oil and propane, capital costs are nearly significantly different between the OBC and the NECH for larger dwellings, with the latter's requirements being consistently higher priced. Again as in Zone 1(A), the savings in annual energy consumption are significant in the case of the NECH. The incremental improvements in ceiling insulation, foundation walls, windows and the installation of an HRV yield significant savings in annual energy costs for these fuels.

Natural gas heated dwellings under either OBC or NECH requirements are effectively identical, however, it appears that the benefits of better performing windows under the NECH outweigh the slight reduction in the effective thermal resistance of wall assemblies.

In Zone 2(B), from the perspective of capital and annual operating costs for detached homes, natural gas represents the most cost effective fuel choice in dwellings and electric resistance heating the least cost effective, under both Codes' requirements . However, in the case of row housing, this distinction is less pronounced due to the scale of this built form.

This discussion of results indicates that impacts on first costs are confined primarily to oil and propane heated dwellings. In terms of cost effectiveness, refer to the discussion in the next chapter on life cycle cost analysis.

4. Life Cycle Cost Analysis

Evaluating the economic performance of any system involves an examination of the component costs associated with the system compared to costs of a base case. There are a number of standard practices for making building decisions. Five of these practices have been identified in the ASTM Standards on Building Economics: life cycle costing; benefit-to-cost and savings-to-investment ratios; internal rates of return for investments; net benefit for investments; and payback for investments.[1]

Life cycle costing (LCC) is a widely used method for evaluating the economic performance of energy efficiency improvements and is the approach used in the development of the NECH. The method is valid for acceptance/rejection and design or size decisions.

To the extent possible the LCC assumptions and methodology used to derive the NECH requirements have also been utilized as part of the LCC comparison between the OBC and the NECH of this study.

Life Cycle Cost Methods

Life cycle costs are the sum over a given study period of all of the costs and benefits of an investment decision expressed in present or annual value terms. Present value, sometimes also referred to as present worth, is the value of a future cost or benefit discounted to the present or some other base time. Annual value is a discounted uniform annual amount equivalent to the project costs or benefits.

Typically the costs that are considered in the valuation include the initial investment costs, the maintenance and repair costs, the operating costs and the salvage costs (or benefits). The analysis is conducted across the entire life of the improvement.

Energy planning and decision-making today often also account for externalities. These are costs that are not generally monetized as part of the investment. Externalities take many forms including environmental cost, social costs, economic development benefits, and health costs. Externalities are real costs that generally extend beyond the end user of the goods or service.

[1] American Society for Testing and Materials, *ASTM Standards on Building Economics*, Second Edition, 1992

Life cycle cost modelling differs from payback approaches in that it accounts for benefits that accrue beyond the payback year. Payback approaches to measuring cost effectiveness are misleading because of this. Simple payback measures of cost effectiveness are further flawed because they ignore the time value of money.

It should be clear that life cycle measures of cost effectiveness have their own limitations. A single life cycle cost value gives no indication of the economic merit of a building component. Two or more values are required for comparison. As well, the alternatives being compared must be equivalent in other respects and must be compared over the same study period.

Consider for example the question of whether low emissivity (low-E) windows are cost effective. The analysis is founded on a comparison of the low-E alternative to standard windows or to other window alternatives. In the case of a retrofit decision the low-E windows may be compared to a *do nothing* alternative which entails zero initial cost but higher future costs.

For each window alternative a number of costs must be quantified including: capital costs, energy costs, maintenance costs, and salvage costs. All of the costs are compared in present value or annual value terms. It should be clear that the LCC analysis is useful for determining whether the high initial cost of a building system is economically justified by reductions in future costs, in this case energy, when compared to an alternative with a lower initial cost but higher future costs. If an alternative has both lower initial costs and lower future costs, an LCC is unnecessary.

The procedure used for calculating the life cycle costs for an energy-efficiency improvement involves the following steps:

- identification of objectives, alternatives and constraints;
- establishment of basic assumptions for the analysis;
- compilation of cost data;
- computation and comparison of life cycle costs for each alternative;
- decision based on LCC analysis and consideration of risk, uncertainty, externalities and funding constraints.

Background On NECH Life Cycle Costing Methodology

Adapted from NECH document ***"Life Cycle Cost Analyses for the Selection of Prescriptive Requirements for the Energy Code for Buildings and For Houses - Summary Report (Ontario):***

For each building component, the identified construction costs were plotted against the respective thermal characteristics. A linear regression was undertaken to establish the trend line of incremental cost per incremental RSI. Assemblies that best represented the trend line were selected for the life cycle cost analysis. This process eliminates the higher cost constructions which would not normally be picked in a life cycle cost optimization, since for the same or inferior thermal performance they cost more. Eliminating these points also assists in assessing the life cycle cost results.

This exercise eliminated individual assemblies with unusually low construction costs. If these points were left in, experience shows that the optimization would almost always pick such points, right across the country. Neglecting these points in the selection process eliminates the risk of obtaining a universal prescriptive requirement based on a single data point that could turn out to have been costed in an anomalous fashion. By selecting assemblies that follow the trend line, several assembly techniques and products should be available to meet the code requirements.

Finally, when a particular trend line runs out of practical assemblies at the high end of the RSI range, the next higher cost assembly is picked. This was the case where 100 mm of rigid insulation was felt to be a practical limit of sheathing insulation thickness for the metal ties used in brick veneer construction. The highest RSI option selected thus features a higher thermal resistivity product having a higher cost per RSI that the other selected products which followed the trend line.

Several components were not the subject of direct life cycle cost analysis. Energy options for exposed floors were not identified, nor costed. It was initially thought that the code would feature a mandatory requirement to fill the joist cavities of floors. It was subsequently realized that floors can have as many different constructions as roofs, and that the cost of insulating these, and their resulting performance are likely similar to those of roofs. The requirements for roofs were thus repeated for floors, with the corresponding floor assembly identified.

As well, fixed windows for houses were not evaluated. These were costed and analyzed for a few locations. The optimums for these windows always involved better technologies than the optima for operable windows, which would be featured side-by-side in every house. Rather than prescribe different window technologies depending on whether these were fixed or operable, it was recommended that the same level of technology be called for in the minimum requirement. This was achieved by adding 10 W/m^2 to the to the optimum ER found for operable windows to obtain the equivalent ER for fixed windows. Fixed and operable windows were analyzed separately for buildings.

Finally, options for roofs in contact with the ground (e.g., of an underground shelter) were not costed or analyzed. The values for foundations walls are used in default.

Implementing policy, such as minimizing the impact of the energy code on the first cost of the house or a high energy efficiency and clean environment policy is possible given the data from the lifecycle cost analysis.

Study Period

The study period that is used as the basis for the LCC analysis reflects the investor's time horizon. In some cases the study period will coincide with the service life of the material or system. The annual value approach is often easier to use than the present value analysis particularly where alternatives embody a number of energy efficiency improvements with very different service lives as is often the case with residential systems. The present value approach may require the determination of resale value at a specific point during the service life of the system. This will more than likely be the case where the end of the study period does not coincide with the end of the service life of each system. This valuation may be difficult at times and is compounded where a number of systems are involved as part of the same alternative. In these cases an annual value analysis may be preferred.

This study utilized the same study period used in the derivation of the NECH requirements - 30 years. Because this study is primarily concerned with a comparison between the OBC and the NECH, the problems associated with significantly different service lives between components are not substantial. Refer to Section 3 for more details.

Interest, Inflation and Discount Rate

Determining the discount rate that should be used is not a straightforward task, particularly across many years. The analysis involves an understanding of interest rates and inflation rates.

Inflation is the reduction in purchasing power of money from year to year. LCC analyses can be based on constant dollars or in current dollar terms. Current dollar analyses are often of use when tax implications are to be examined since taxes are tied to current-dollar cash flows rather than constant-dollar cash flows. Government and homeowner expenditure decisions where there are no tax implications are often more easily analysed using a constant-dollar approach.

The discount rate that is selected should reflect the investor's time value of money. In other words, the discount rate should reflect the rate of interest that makes the investor indifferent between paying or receiving a dollar now or at some future point in time. The discount rate is used to compare costs and benefits occurring at different points in time to equivalent dollars at a common point in time.

The discount rate generally refers to the best rate of return that is available for the investor's funds. For some investors, the rate of return is mandated and defines the discount rate that should be used. In some analyses the discount rate has at times been used as a reflection of investor utility. It has been used for instance to account for differing objectives when comparing alternatives - a kitchen upgrade versus low-E windows for example. In this case a strict LCC analysis would reveal the low-E upgrade to provide greater economic benefits. If economic considerations were the only measures of purchaser utility, all purchasers would choose the low-E windows. Given that this doesn't happen, it should be obvious that economics is not the only consideration for the purchaser. Lifestyle, aesthetics, comfort, ease of use, and resale value may be among the purchaser's considerations - part of the purchasers utility function.

Artificially manipulating the discount rate to reflect the purchaser's utility takes a measure of economic performance and demands other things of it. The validity of results using this approach are open to question. In this study, discount rate will be discussed strictly as an economic tool. It will not embody the full spectrum of variables that comprise the purchasers decision-making function.

The discount rate can be expressed as a nominal rate or a real rate. The real discount rate refers to the real earning power of money over time. The nominal discount rate reflects the time value of money stemming from both inflation and the discount rate.

The nominal discount rate, the rate of inflation and the real discount rate used as part of this study and as part of the derivation of the NECH requirements are summarized in Table 4.1 below:

Table 4.1 **NECH Economic Assumptions**	
INTEREST RATE	9 %
INFLATION RATE	3 %
DISCOUNT RATE	6 %

Building Component Costs

The evaluation of building component costs are generally based on a quantity survey approach with field corroboration. The total capital cost of construction must be estimated including: material cost, labour cost, subcontract costs, taxes, bonds, insurance, overheads, contingencies and profit.

The determination of the capital costs involved in construction must account for local market conditions such as the limited availability of materials and skilled labour as well as price variations and anomalies. Estimating the salvage value of the alternative can be a challenging task. In many cases estimating a zero salvage value is conservative.

A complete discussion of the capital costs associated with the NECH and OBC alternatives is presented in Section 3 of this report. Refer to it for more details.

Energy Costs

The analysis of energy costs involves determining the energy consumption associated with each alternative and converting that into an energy cost.

As detailed in the previous section, HOT-2000 was used to simulate the energy performance of the buildings. HOT-2000 calculated the energy consumption on whole house basis showing the performance of individual components. The whole house energy consumption should be used as opposed to a component consumption since the whole house value accounts for system interactions where a component consumption does not. For example, considering the low-E window upgrade from above. HOT-2000 will provide the energy consumption associated with the low-E windows. This value should not be used without considering the effect of the windows on solar gains. In addition, interactions between losses, gains and allowable temperature swings within the building demand the whole house energy consumption be used. Section 3 details the methodology used to derive the energy consumption and operating costs associated with all of the alternatives.

Energy prices are based on projected real prices across the study period. Tables 4.2, 4.3 and 4.4 identify the energy price forecasts used as part of this study. These energy price projections were also those used in the development of the NECH provisions; however, these are presented in real 1994 dollars.

The operating cost factor (OCF) accounts for the escalation of energy prices across the entire study period, escalation exclusive of inflation. The OCF applied to the energy consumption of the building results in present value operating costs for each alternative.

Table 4.2
Operating Cost Factors

Study Period - 30 years

FUEL	OPERATING COST FACTOR
ELECTRICITY	36.0 cents/MJ
NATURAL GAS	9.50 cents/MJ
OIL	15.8 cents/MJ
PROPANE	22.0 cents/MJ

Table 4.3
1994 Base Prices for Energy

ELECTRICITY	9.03 ¢/kWh (25.08 $/GJ)
NATURAL GAS	5.94 $/GJ
OIL	10.1 $/GJ
PROPANE	14.08 $/GJ

Table 4.4
Ontario Retail Price Forecast, Residential Sector
(real 1994 prices)

	ELECTRICITY PRICES		NATURAL GAS PRICES		LIGHT FUEL OIL PRICES		PROPANE PRICES	
year	CENTS/MJ	%CH	CENTS/MJ	%CH	CENTS/MJ	%CH	CENTS/MJ	%CH
1994	2.51		0.59		1.01		1.41	
1995	2.52	0.4	0.6	1.4	1.02	1.2	1.43	1.2
1996	2.53	0.4	0.61	1.4	1.03	1.2	1.44	1.2
1997	2.54	0.4	0.62	1.4	1.05	1.2	1.46	1.2
1998	2.55	0.4	0.63	1.4	1.06	1.2	1.48	1.2
1999	2.56	0.4	0.64	1.4	1.07	1.2	1.5	1.2
2000	2.57	0.4	0.65	1.4	1.09	1.2	1.51	1.2
2001	2.58	0.4	0.66	1.4	1.1	1.2	1.53	1.2
2002	2.59	0.4	0.66	1.4	1.11	1.2	1.55	1.2
2003	2.6	0.4	0.67	1.4	1.12	1.2	1.57	1.2
2004	2.61	0.4	0.68	1.4	1.14	1.2	1.59	1.2
2005	2.62	0.4	0.69	1.4	1.15	1.2	1.61	1.2
2006	2.63	0.4	0.7	1.4	1.17	1.2	1.63	1.2
2007	2.64	0.4	0.71	1.4	1.18	1.2	1.64	1.2
2008	2.65	0.4	0.72	1.4	1.19	1.2	1.66	1.2
2009	2.66	0.4	0.73	1.4	1.21	1.2	1.68	1.2
2010	2.67	0.4	0.74	1.4	1.22	1.2	1.7	1.2
2011	2.68	0.4	0.75	1.4	1.24	1.2	1.73	1.2
2012	2.7	0.4	0.76	1.4	1.25	1.2	1.75	1.2
2013	2.71	0.4	0.77	1.4	1.27	1.2	1.77	1.2
2014	2.72	0.4	0.78	1.4	1.28	1.2	1.79	1.2
2015	2.73	0.4	0.8	1.4	1.3	1.2	1.81	1.2
2016	2.74	0.4	0.81	1.4	1.31	1.2	1.83	1.2
2017	2.75	0.4	0.82	1.4	1.33	1.2	1.85	1.2
2018	2.76	0.4	0.83	1.4	1.35	1.2	1.88	1.2
2019	2.77	0.4	0.84	1.4	1.36	1.2	1.9	1.2
2020	2.78	0.4	0.85	1.4	1.38	1.2	1.92	1.2
2021	2.79	0.4	0.87	1.4	1.39	1.2	1.94	1.2
2022	2.81	0.4	0.88	1.4	1.41	1.2	1.97	1.2
2023	2.82	0.4	0.89	1.4	1.43	1.2	1.99	1.2
2024	2.83	0.4	0.9	1.4	1.45	1.2	2.01	1.2

Externalities

The burdens that a barrel of oil or kilowatt-hour of electricity imposes beyond its stated price are what economists call externalities: costs borne by people who are not parties to the transaction that imposes them. For more than two decades, environmental economists and ecologists have been struggling to identify and measure the external costs of energy production and consumption. Meanwhile conventional economics and current market policy ignore externalities, effectively setting their cost to zero.[2]

Externalities are costs that are not embodied as part of the cost of the alternative. They typically are associated with, but not necessarily limited to, energy generation and transmission. Externalities are also associated with most human activities. Most industrial processes impose some burden on earth, water or atmosphere that is not captured as part of the price of the product produced. There is no part of the product's price that is targeted to eliminating the burden. Effluent, tailings, emissions, wastes, these are all impacts of industrial processes that are often left to the biosphere to absorb and are often manifested as real costs.

Externalities related to energy generation and transmission include acid gas production within the regulation, greenhouse gas production, land flooding etc. Health and social costs are also incurred but are more difficult to ascribe to energy generation and transmission.

The monetization of externalities be they infrastructure costs, environmental costs or health costs is a difficult exercise. The diffuse and non-specific nature of externalities contributes to the difficulty of the task. Hubbard cites as example the health effects of air pollution. The question of how to assign costs to increased lung disease among seniors or lead poisoning in children from air pollution is unresolved.

Assigning costs to air pollution from a specific source further complicates the question. Issues such as whether the impact in one group is more costly than the other make the task of assigning cost extremely challenging.

Other externalities not quantified include the increased levels of comfort that typically result from better insulated envelopes. The control of dust and allergens in houses with tight envelopes and central ventilation systems, for example, are benefits both in terms of health and comfort. The impact of these benefits to the general economy are often manifested as increased worker productivity or decreased incidence of illness.

2 Hubbard, Harold M., "The Real Cost of Energy", Scientific American, Volume 264, Number 4, April 1991

By the same token, positive benefits from the generation and production of energy are also sometimes not accounted for. The control of rivers to permit navigation, the creation of parks, the economic activity and employment are examples of the positive benefits that result from the production of energy.

The monetization of externalities is by no means an easy task. Establishing some type of consensus becomes an even greater challenge. In a number of jurisdictions the difficulty of the analysis has not paralyzed the monetization process. A surrogate value for these external costs is sometimes assigned to the cost of energy and used as part of the planning process. The adder ranges typically from 10 to 25% of the price of the energy. It should be clear that adders will be specific to the source of the energy be it electricity, natural gas or oil. Further the adder for electricity will depend on the sources of the electricity be they hydro-electricity, nuclear, coal or natural gas. Electricity generated primarily from coal-burning will likely have a greater environmental impact that if it were generated from the burning of gas.

This LCC analysis does not consider externalities. These are discussed in detail in the section that follows.

Life Cycle Costing Results

Tables 4.5 and 4.6 summarize differences in capital and operating costs between the National Energy Code for Housing and the Ontario Building Code for both degree-day zones. The life cycle cost analysis results of the comparison between the requirements of the OBC and of the NECH for both Zone 1 and Zone 2 are presented in Tables 4.7 and 4.8. These tables present the life cycle costs for the six houses equipped with the seven heating systems.

The data indicate, in general, that the National Energy Code for Housing would provide insignificant energy and cost savings for the vast majority of new home buyers in Ontario. Nonetheless, it would provide savings to new home purchasers whose buildings are heated with oil, propane and in most cases for those using heat pumps, both air and ground source. At the present time, for gas and electrically heated homes in Ontario there are no significant life cycle cost benefits from moving from the Ontario Building Code to the National Energy Code for Housing.

Table 4.5
Incremental Capital and Operating Costs - ZONE 1

	OBC	NECH			OBC	NECH	
HOUSE ID	CAPITAL COSTS	CAPITAL COSTS	INC. CAP. COSTS		PV OP. COSTS	PV OP. COSTS	INC. OP. COSTS
TTLOEEH	$45,389	$46,126	$737		$11,243	$10,791	($452)
TTLOASH	$49,302	$47,170	($2,132)		$6,584	$7,679	$1,095
TTLOGSH	$59,056	$55,437	($3,619)		$4,922	$7,086	$2,164
TTLOMOF	$42,593	$44,399	$1,806		$11,236	$8,605	($2,631)
TTLOMPF	$42,593	$44,399	$1,806		$15,005	$11,374	($3,631)
TTLOMGF	$42,593	$42,912	$319		$7,422	$7,420	($2)
TTLOHGF	$43,870	$44,189	$319		$6,655	$6,652	($3)
TTSOEEH	$35,658	$36,199	$541		$7,482	$7,187	($295)
TTSOASH	$39,604	$37,915	($1,689)		$4,693	$5,498	$805
TTSOGSH	$49,630	$46,666	($2,964)		$3,628	$5,751	$2,123
TTSOMOF	$33,892	$35,415	$1,523		$8,519	$6,099	($2,420)
TTSOMPF	$33,892	$35,415	$1,523		$11,229	$7,901	($3,328)
TTSOMGF	$33,892	$34,140	$248		$5,777	$5,753	($24)
TTSOHGF	$35,169	$35,417	$248		$5,225	$5,204	($21)
TBSOEEH	$35,820	$36,385	$565		$9,591	$9,095	($496)
TBSOASH	$39,767	$38,686	($1,081)		$5,699	$6,327	$628
TBSOGSH	$49,792	$47,194	($2,598)		$5,150	$6,558	$1,408
TBSOMOF	$34,495	$36,187	$1,692		$9,784	$7,105	($2,679)
TBSOMPF	$34,495	$36,187	$1,692		$12,975	$9,288	($3,687)
TBSOMGF	$34,495	$34,669	$174		$6,554	$6,575	$21
TBSOHGF	$35,772	$35,946	$174		$5,905	$5,923	$18
TSDOEEH	$26,770	$27,138	$368		$7,078	$6,806	($272)
TSDOASH	$30,716	$29,479	($1,237)		$4,494	$5,106	$612
TSDOGSH	$40,742	$38,400	($2,342)		$3,490	$5,500	$2,010
TSDOMOF	$25,760	$26,979	$1,219		$8,032	$5,639	($2,393)
TSDOMPF	$25,760	$26,979	$1,219		$10,546	$7,260	($3,286)
TSDOMGF	$25,760	$25,875	$115		$5,488	$5,506	$18
TSDOHGF	$27,037	$27,152	$115		$4,976	$4,992	$16
TREOEEH	$24,220	$24,543	$323		$4,626	$4,434	($192)
TREOASH	$28,167	$27,155	($1,012)		$3,258	$3,712	$454
TREOGSH	$38,192	$36,106	($2,086)		$2,611	$4,530	$1,919
TREOMOF	$23,463	$24,656	$1,193		$6,378	$3,974	($2,404)
TREOMPF	$23,463	$24,656	$1,193		$8,261	$4,967	($3,294)
TREOMGF	$23,463	$23,581	$118		$4,472	$4,500	$28
TREOHGF	$24,740	$24,858	$118		$4,089	$4,113	$24
TRIOEEH	$17,507	$17,828	$321		$2,882	$2,729	($153)
TRIOASH	$21,454	$20,981	($473)		$2,338	$2,514	$176
TRIOGSH	$31,480	$30,086	($1,394)		$1,985	$3,387	$1,402
TRIOMOF	$17,416	$18,482	$1,066		$4,561	$2,658	($1,903)
TRIOMPF	$17,416	$18,482	$1,066		$5,758	$3,159	($2,599)
TRIOMGF	$17,416	$17,561	$145		$3,350	$3,339	($11)
TRIOHGF	$18,693	$18,838	$145		$3,107	$3,097	($10)

Table 4.6
Incremental Capital and Operating Costs - ZONE 2

	OBC	NECH			OBC	NECH	
HOUSE ID	CAPITAL COSTS	CAPITAL COSTS	INC. CAP COSTS		PV OP. COSTS	PV OP. COSTS	INC. OP. COSTS
STLOEEH	$45,389	$46,718	$1,329		$16,033	$14,743	($1,290)
STLOASH	$49,302	$48,990	($312)		$9,733	$9,643	($90)
STLOGSH	$59,056	$57,005	($2,051)		$6,644	$7,841	$1,197
STLOMOF	$44,156	$46,219	$2,063		$13,680	$10,204	($3,476)
STLOMPF	$44,156	$46,219	$2,063		$18,367	$13,564	($4,803)
STLOMGF	$44,156	$44,479	$323		$8,938	$7,843	($1,095)
STLOHGF	$45,433	$45,756	$323		$7,985	$7,977	($8)
STSOEEH	$35,658	$36,630	$972		$10,791	$9,921	($870)
STSOASH	$39,604	$39,319	($285)		$6,732	$6,700	($32)
STSOGSH	$49,630	$48,005	($1,625)		$4,824	$5,833	$1,009
STSOMOF	$35,108	$36,819	$1,711		$10,260	$7,066	($3,194)
STSOMPF	$35,108	$36,819	$1,711		$13,610	$9,210	($4,400)
STSOMGF	$35,108	$35,480	$372		$6,869	$5,748	($1,121)
STSOHGF	$36,385	$36,757	$372		$6,188	$5,203	($985)
SBSOEEH	$35,820	$36,863	$1,043		$14,389	$13,115	($1,274)
SBSOASH	$39,767	$39,788	$21		$8,611	$8,401	($210)
SBSOGSH	$49,792	$48,428	($1,364)		$6,105	$6,477	$372
SBSOMOF	$35,396	$37,288	$1,892		$11,803	$9,033	($2,770)
SBSOMPF	$35,396	$37,288	$1,892		$15,744	$11,926	($3,818)
SBSOMGF	$35,396	$35,903	$507		$7,815	$7,115	($700)
SBSOHGF	$36,673	$37,180	$507		$7,013	$6,395	($618)
SSDOEEH	$26,770	$27,499	$729		$10,147	$9,353	($794)
SSDOASH	$30,716	$30,553	($163)		$6,440	$6,367	($73)
SSDOGSH	$40,742	$39,580	($1,162)		$4,664	$5,455	$791
SSDOMOF	$26,678	$28,053	$1,375		$9,771	$6,738	($3,033)
SSDOMPF	$26,678	$28,053	$1,375		$12,924	$8,751	($4,173)
SSDOMGF	$26,678	$27,054	$376		$6,580	$5,365	($1,215)
SSDOHGF	$27,955	$28,331	$376		$5,938	$4,944	($994)
SREOEEH	$24,220	$24,832	$612		$6,709	$6,150	($559)
SREOASH	$28,167	$28,028	($139)		$4,577	$4,538	($39)
SREOGSH	$38,192	$37,178	($1,014)		$3,407	$4,196	$789
SREOMOF	$24,210	$25,528	$1,318		$7,682	$4,685	($2,997)
SREOMPF	$24,210	$25,528	$1,318		$10,034	$5,917	($4,117)
SREOMGF	$24,210	$24,653	$443		$5,302	$4,122	($1,180)
SREOHGF	$25,487	$25,930	$443		$4,823	$3,787	($1,036)
SRIOEEH	$17,507	$18,036	$529		$4,309	$3,913	($396)
SRIOASH	$21,454	$21,462	$8		$3,278	$3,205	($73)
SRIOGSH	$31,480	$30,969	($511)		$2,551	$3,567	$1,016
SRIOMOF	$17,810	$18,962	$1,152		$5,573	$3,138	($2,435)
SRIOMPF	$17,810	$18,962	$1,152		$7,122	$3,784	($3,338)
SRIOMGF	$17,810	$18,444	$634		$4,005	$2,901	($1,104)
SRIOHGF	$19,087	$19,721	$634		$3,689	$2,718	($971)

Table 4.7
Life Cycle Cost Summary- ZONE 1

	OBC				NECH				
HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	SAVINGS	
TTLOEEH	$45,389	$11,243	$56,632	TTLNEEH	$46,126	$10,791	$56,918	($286)	
TTLOASH	$49,302	$6,584	$55,886	TTLNASH	$47,170	$7,679	$54,849	$1,037	N
TTLOGSH	$59,056	$4,922	$63,978	TTLNGSF	$55,437	$7,086	$62,523	$1,455	N
TTLOMOF	$42,593	$11,236	$53,829	TTLNMOH	$44,399	$8,605	$53,003	$826	N
TTLOMPF	$42,593	$15,005	$57,598	TTLNMPH	$44,399	$11,374	$55,773	$1,825	N
TTLOMGF	$42,593	$7,422	$50,015	TTLNMGF	$42,912	$7,420	$50,331	($316)	
TTLOHGF	$43,870	$6,655	$50,526	TTLNHGF	$44,189	$6,652	$50,841	($315)	
TTSOEEH	$35,658	$7,482	$43,140	TTSNEEH	$36,199	$7,187	$43,386	($245)	
TTSOASH	$39,604	$4,693	$44,297	TTSNASH	$37,915	$5,498	$43,413	$885	N
TTSOGSH	$49,630	$3,628	$53,258	TTSNGSF	$46,666	$5,751	$52,417	$841	N
TTSOMOF	$33,892	$8,519	$42,411	TTSNMOH	$35,415	$6,099	$41,514	$897	N
TTSOMPF	$33,892	$11,229	$45,121	TTSNMPH	$35,415	$7,901	$43,316	$1,805	N
TTSOMGF	$33,892	$5,777	$39,669	TTSNMGF	$34,140	$5,753	$39,893	($224)	
TTSOHGF	$35,169	$5,225	$40,395	TTSNHGF	$35,417	$5,204	$40,622	($227)	
TBSOEEH	$35,820	$9,591	$45,411	TBSNEEH	$36,385	$9,095	$45,480	($69)	
TBSOASH	$39,767	$5,699	$45,466	TBSNASH	$38,686	$6,327	$45,013	$453	
TBSOGSH	$49,792	$5,150	$54,942	TBSNGSF	$47,194	$6,558	$53,752	$1,190	N
TBSOMOF	$34,495	$9,784	$44,279	TBSNMOH	$36,187	$7,105	$43,292	$987	N
TBSOMPF	$34,495	$12,975	$47,470	TBSNMPH	$36,187	$9,288	$45,475	$1,996	N
TBSOMGF	$34,495	$6,554	$41,050	TBSNMGF	$34,669	$6,575	$41,244	($194)	
TBSOHGF	$35,772	$5,905	$41,678	TBSNHGF	$35,946	$5,923	$41,869	($192)	
TSDOEEH	$26,770	$7,078	$33,848	TSDNEEH	$27,138	$6,806	$33,945	($96)	
TSDOASH	$30,716	$4,494	$35,210	TSDNASH	$29,479	$5,106	$34,585	$625	N
TSDOGSH	$40,742	$3,490	$44,232	TSDNGSF	$38,400	$5,500	$43,900	$332	
TSDOMOF	$25,760	$8,032	$33,792	TSDNMOH	$26,979	$5,639	$32,618	$1,174	N
TSDOMPF	$25,760	$10,546	$36,306	TSDNMPH	$26,979	$7,260	$34,239	$2,067	N
TSDOMGF	$25,760	$5,488	$31,248	TSDNMGF	$25,875	$5,506	$31,381	($133)	
TSDOHGF	$27,037	$4,976	$32,014	TSDNHGF	$27,152	$4,992	$32,144	($131)	
TREOEEH	$24,220	$4,626	$28,847	TRENEEH	$24,543	$4,434	$28,977	($130)	
TREOASH	$28,167	$3,258	$31,425	TRENASH	$27,155	$3,712	$30,867	$557	N
TREOGSH	$38,192	$2,611	$40,803	TRENGSF	$36,106	$4,530	$40,636	$167	
TREOMOF	$23,463	$6,378	$29,840	TRENMOH	$24,656	$3,974	$28,630	$1,211	N
TREOMPF	$23,463	$8,261	$31,724	TRENMPH	$24,656	$4,967	$29,623	$2,101	N
TREOMGF	$23,463	$4,472	$27,934	TRENMGF	$23,581	$4,500	$28,080	($146)	
TREOHGF	$24,740	$4,089	$28,828	TRENHGF	$24,858	$4,113	$28,971	($143)	
TRIOEEH	$17,507	$2,882	$20,389	TRINEEH	$17,828	$2,729	$20,557	($168)	
TRIOASH	$21,454	$2,338	$23,792	TRINASH	$20,981	$2,514	$23,496	$296	
TRIOGSH	$31,480	$1,985	$33,465	TRINGSF	$30,086	$3,387	$33,473	($8)	
TRIOMOF	$17,416	$4,561	$21,977	TRINMOH	$18,482	$2,658	$21,139	$838	N
TRIOMPF	$17,416	$5,758	$23,174	TRINMPH	$18,482	$3,159	$21,641	$1,533	N
TRIOMGF	$17,416	$3,350	$20,766	TRINMGF	$17,561	$3,339	$20,900	($133)	
TRIOHGF	$18,693	$3,107	$21,800	TRINHGF	$18,838	$3,097	$21,935	($135)	

Table 4.8
Life Cycle Cost Summary - ZONE 2

	OBC					NECH				
HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC		HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	SAVINGS	
STLOEEH	$45,389	$16,033	$61,422		STLNEEH	$46,718	$14,743	$61,462	($40)	
STLOASH	$49,302	$9,733	$59,035		STLNASH	$48,990	$9,643	$58,633	$402	
STLOGSH	$59,056	$6,644	$65,700		STLNGSH	$57,005	$7,841	$64,846	$854	N
STLOMOF	$44,156	$13,680	$57,836		STLNMOH	$46,219	$10,204	$56,423	$1,413	N
STLOMPF	$44,156	$18,367	$62,523		STLNMPH	$46,219	$13,564	$59,783	$2,740	N
STLOMGF	$44,156	$8,938	$53,094		STLNMGH	$44,479	$7,843	$52,322	$772	N
STLOHGF	$45,433	$7,985	$53,418		STLNHGH	$45,756	$7,977	$53,733	($316)	
STSOEEH	$35,658	$10,791	$46,449		STSNEEH	$36,630	$9,921	$46,551	($102)	
STSOASH	$39,604	$6,732	$46,337		STSNASH	$39,319	$6,700	$46,019	$318	
STSOGSH	$49,630	$4,824	$54,454		STSNGSH	$48,005	$5,833	$53,838	$616	N
STSOMOF	$35,108	$10,260	$45,368		STSNMOH	$36,819	$7,066	$43,886	$1,482	N
STSOMPF	$35,108	$13,610	$48,718		STSNMPH	$36,819	$9,210	$46,029	$2,689	N
STSOMGF	$35,108	$6,869	$41,977		STSNMGH	$35,480	$5,748	$41,228	$749	N
STSOHGF	$36,385	$6,188	$42,573		STSNHGH	$36,757	$5,203	$41,960	$612	N
SBSOEEH	$35,820	$14,389	$50,209		SBSNEEH	$36,863	$13,115	$49,977	$232	
SBSOASH	$39,767	$8,611	$48,378		SBSNASH	$39,788	$8,401	$48,188	$189	
SBSOGSH	$49,792	$6,105	$55,897		SBSNGSH	$48,428	$6,477	$54,905	$992	N
SBSOMOF	$35,396	$11,803	$47,199		SBSNMOH	$37,288	$9,033	$46,321	$878	N
SBSOMPF	$35,396	$15,744	$51,140		SBSNMPH	$37,288	$11,926	$49,214	$1,926	N
SBSOMGF	$35,396	$7,815	$43,211		SBSNMGH	$35,903	$7,115	$43,018	$193	N
SBSOHGF	$36,673	$7,013	$43,686		SBSNHGH	$37,180	$6,395	$43,575	$112	N
SSDOEEH	$26,770	$10,147	$36,917		SSDNEEH	$27,499	$9,353	$36,851	$66	
SSDOASH	$30,716	$6,440	$37,157		SSDNASH	$30,553	$6,367	$36,919	$238	
SSDOGSH	$40,742	$4,664	$45,407		SSDNGSH	$39,580	$5,455	$45,035	$372	
SSDOMOF	$26,678	$9,771	$36,449		SSDNMOH	$28,053	$6,738	$34,791	$1,658	N
SSDOMPF	$26,678	$12,924	$39,602		SSDNMPH	$28,053	$8,751	$36,804	$2,798	N
SSDOMGF	$26,678	$6,580	$33,257		SSDNMGH	$27,054	$5,365	$32,419	$838	N
SSDOHGF	$27,955	$5,938	$33,893		SSDNHGH	$28,331	$4,944	$33,276	$617	N
SREOEEH	$24,220	$6,709	$30,929		SRENEEH	$24,832	$6,150	$30,982	($53)	
SREOASH	$28,167	$4,577	$32,744		SRENASH	$28,028	$4,538	$32,565	$178	
SREOGSH	$38,192	$3,407	$41,600		SRENGSH	$37,178	$4,196	$41,374	$225	
SREOMOF	$24,210	$7,682	$31,892		SRENMOH	$25,528	$4,685	$30,213	$1,678	N
SREOMPF	$24,210	$10,034	$34,244		SRENMPH	$25,528	$5,917	$31,445	$2,799	N
SREOMGF	$24,210	$5,302	$29,511		SRENMGH	$24,653	$4,122	$28,775	$737	N
SREOHGF	$25,487	$4,823	$30,310		SRENHGH	$25,930	$3,787	$29,716	$593	N
SRIOEEH	$17,507	$4,309	$21,816		SRINEEH	$18,036	$3,913	$21,949	($133)	
SRIOASH	$21,454	$3,278	$24,731		SRINASH	$21,462	$3,205	$24,668	$64	
SRIOGSH	$31,480	$2,551	$34,031		SRINGSH	$30,969	$3,567	$34,537	($506)	O
SRIOMOF	$17,810	$5,573	$23,382		SRINMOH	$18,962	$3,138	$22,100	$1,282	N
SRIOMPF	$17,810	$7,122	$24,932		SRINMPH	$18,962	$3,784	$22,747	$2,185	N
SRIOMGF	$17,810	$4,005	$21,814		SRINMGH	$18,444	$2,901	$21,345	$469	
SRIOHGF	$19,087	$3,689	$22,776		SRINHGH	$19,721	$2,718	$22,439	$337	

5. ENVIRONMENTAL IMPLICATIONS

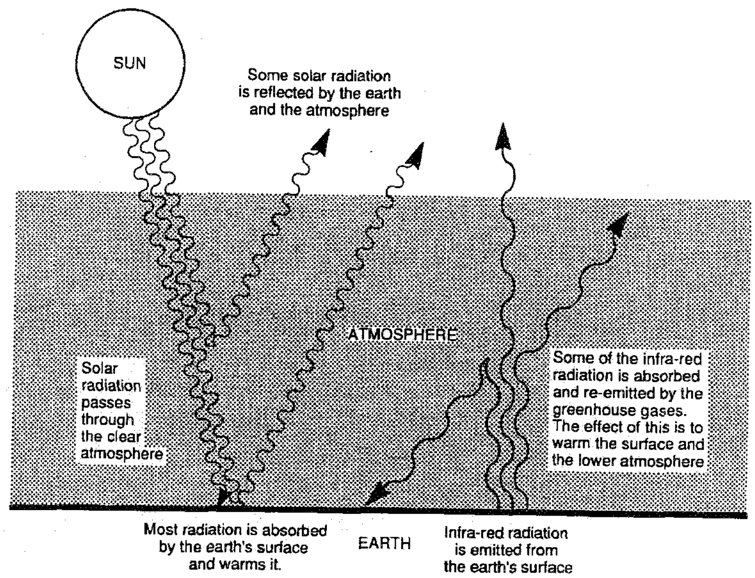
Climate change and global warming have been the subject of intensive investigation provincially, nationally and internationally for a number of years. While the complexity of the global climate change phenomena makes prediction difficult, the world's leading scientists assembled by the Intergovernmental Panel on Climate Change suggest that mean global temperature will increase given current patterns of greenhouse gas (GHG) production.[1]

The greenhouse effect is a relatively well-understood phenomena described as early as 1827 by Jean-Baptiste Fourier. The blanketing effect of the earth's atmosphere acting like the panes of glass of a greenhouse impede the re-radiation of long wave radiation back into space. The trapped heat energy acts to increase the earth's equilibrium temperature. The current global warming concerns are centred on the additional warming that may result from rapidly increasing concentrations of heat-trapping greenhouse gases, in particular from the anthropogenic sources of carbon dioxide, methane, nitrous oxide and chlorinated fluorocarbons. Global surface temperatures are about 33 °C warmer than would otherwise be expected because of the greenhouse effect.[2]

[1] Intergovernmental Panel on Climate Change, *Scientific Assessment of Climate Change,* Report prepared for the Intergovernmental Panel on Climate Change, Working Group 1, Bracknell, U.K., 1990

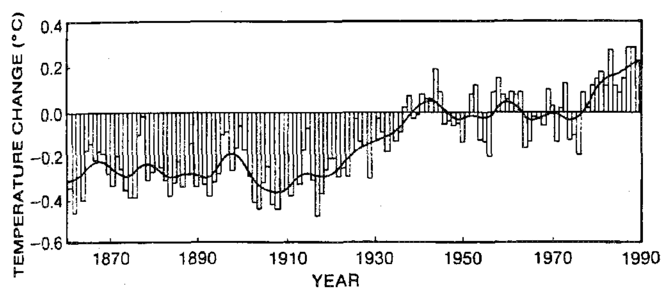
[2] Schneider, S.H, *The Changing Climate, Scientific American, 261, No.3, September 1989, qtd.* page 2, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

Figure 1
The Greenhouse Effect



page xiv, Intergovernmental Panel on Climate Change, *Scientific Assessment of Climate Change*

Figure 2
Global-mean combined land-air and sea-surface temperatures, 1861-1989, relative to the average for 1951-80



page xxix, Intergovernmental Panel on Climate Change, *Scientific Assessment of Climate Change*

The concern over global warming results from the potential social and economic impacts associated with changes in mean surface temperatures. The potential effects of global climate change include:

- a rise in global mean surface air temperatures with a disproportionate increase towards the north and south poles;
- fluctuations in daily and seasonal weather patterns including an increased number and severity of tropical storms;
- a rise in sea level increasing potential flooding of coastal areas;
- changes in distribution and seasonal availability of fresh water resources;
- accelerated animal extinction resulting from increased habitat stress including decreased biological diversity; and
- altered yield and productivity of natural and managed ecosystems;

"If steps are not taken to reduce greenhouse gas emissions, a doubling of carbon equivalent concentrations from the pre-industrial level is anticipated by 2025. The Intergovernmental Panel on Climate Change anticipates that doubling of carbon equivalent concentrations could cause temperature change in the range of 1.9 to 5.2 degrees Celcius with 2.5 degrees as the best estimate"

- page 2, Canadian Institute for Environmental Law and Policy, *Carbon Dioxide Reduction Options for Ontario: A Discussion Paper*, Toronto, August 1994

The principal long-lived gases responsible for absorbing outgoing radiation are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs). A number of gases may also indirectly affect global warming. Carbon monoxide (CO), nitrogen oxides (NO_x), non-methane hydrocarbons (NMHC), and methane are all thought to contribute indirectly to global warming by affecting the concentration of other greenhouse gases. The contributions of these gases to global warming is more uncertain than the direct greenhouse gases.

Carbon dioxide (CO_2) is particularly noteworthy as an important absorber of infrared radiation. CO_2, from human-caused emissions and fossil fuel combustion, is by far the most significant greenhouse gas globally. In Canada, CO_2 emissions accounted for approximately 70% of human-caused greenhouse gas emissions in 1990 while fossil fuel combustion accounted for about 94% of CO_2 emissions.[3] Both methane and nitrous oxide are also emitted from the production and use of energy, however, their contributions to global warming are much smaller. The global warming potential for a variety of greenhouse gases have been identified. These are detailed on the pages to follow.

The Government of Canada and the Government of Ontario have both committed nationally and internationally to the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, allowing ecosystems to adapt naturally to climate change and ensuring that food production is not threatened. Both governments have committed to stabilization at 1990 levels by the year 2000. Less formal commitments exist for reduction of emissions from 1988 levels by 20% by the year 2005.

While a number of studies including the COGGER Panel report suggest these targets are feasible and cost-effective to achieve, many of these studies are based on broad economic measures. End use energy forecasting in particular tends to spring from the examination of primary energy end use consumption trends as derived from a number of economic variables.

These studies do not permit the examination of technological scenarios, particularly as applied to actual buildings, as a means of validating conclusions with respect to feasibility and cost-effectiveness. While trend analysis may prove useful from a larger policy development viewpoint, it is limited in usefulness when examining technological alternatives, particularly of the type suggested by Building Code changes.

3 page xv, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

This study attempts to draw conclusion from the effects at the household level of applying the varying requirements of the Ontario Building Code and those of the National Energy Code for Housing. This study will attempt to quantify at the micro-level emissions from residential heating appliances with a special focus on greenhouse gas emissions. Specifically, the approach used as part of this study:

- details the government commitments to greenhouse gas reduction;
- describes greenhouse gases and sources of emissions;
- simulates the energy performance of archetype houses in two locations in Ontario;
- examines the emissions associated with space heating for each house type;
- examines environmental implications that might result from the adoption of the National Energy Code for Housing in Ontario;
- attempts to quantify the externalities associated with the emissions from residential space heating for new houses.

The COGGER Panel addresses public policy that imparts economic benefits in addition to those resulting in greenhouse gas emissions.[4] This type of policy is known as a "no regrets" or "worth doing anyway" policy. This study attempts to address environmental implications including the cost effectiveness of adopting the National Energy Code for Housing in Ontario by not only examining traditional lifecycle costs but by also examining costs associated with energy use emissions.

[4] page 3, COGGER Panel, Canadian Options for Greenhouse Gas Emission Reduction, Canadian Global Change Program, The Royal Society of Canada, Technical Report Series No. 93-1, September 1993

Government Commitment To Greenhouse Gas Reduction

In 1992 Canada became a signatory to the United Nations Framework Convention on Climate Change at the UN Earth Summit in Rio de Janeiro. Canada committed to the

stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

- Article 2, United Nations Framework Convention on Climate Change, New York, 1992.

The UN framework does not contain a timetable for the stabilization. Nevertheless, the Government of Canada has committed to stabilizing Canada's greenhouse gas emissions at the 1990 level by the year 2000. Less formal commitments by the federal Minister of the Environment support the objective of cutting carbon dioxide emissions by 20% from 1988 levels by the year 2005.

In Ontario, the provincial government has committed to stabilizing Ontario's greenhouse gas emissions, at the 1990 level, by the year 2000. Further, on June 9, 1994 the Ontario Legislature supported the federal government commitment to a 20% reduction in Canada's greenhouse gas emissions over 1988 levels by 2005.

The Intergovernmental Panel on Climate Change concluded in 1990 that the following immediate reductions from current emissions are required to stabilize atmospheric concentrations of GHGs by about 2050[5]:

CO_2 > 60%;
CH_4 - 70-80%;
N_2O - 15-20%;
CFCs - 70-85%;
HCFCs - 40-50%.

[5] Intergovernmental Panel on Climate Change, *Scientific Assessment of Climate Change,* Report prepared for the Intergovernmental Panel on Climate Change, Working Group 1, Bracknell, U.K., 1990
qtd. page 1, COGGER Panel, Canadian Options for Greenhouse Gas Emission Reduction, Canadian Global Change Program, The Royal Society of Canada, Technical Report Series No. 93-1, September 1993

Scientific knowledge of the likely magnitude and impacts of global warming due to human-caused emissions of greenhouse gases is still subject to considerable uncertainty. What is clear, however, is that reducing CO_2 emissions by 60% will require fundamental changes to Canadian and global energy supply and use patterns. Cost appears to be the key issue to reducing GHG emissions.

The factors that rise to greenhouse gas emissions are a starting point in formulating approaches to mitigation. The COGGER Panel identified the six factors as follows[6] :

- greenhouse emissions per unit of fossil fuel combustion
- the proportion of fossil fuels per unit of total domestic energy production
- total domestic energy production per unit of final energy use
- the efficiency of final energy use per unit of economic activity
- economic activity per person
- the number of people in Canada

Examining these factors suggests that greenhouse gas emissions could be lowered by: greater reliance on lower emission fuels (e.g. natural gas versus oil); greater reliance on non-fossil energy sources; increased conversion and process efficiencies and exergies; shift toward non-energy intensive industries; and, increased levels of labour productivity.

This study focuses primarily on increased energy efficiency as a means of reducing greenhouse gas and other emissions.

6 page 2, COGGER Panel, Canadian Options for Greenhouse Gas Emission Reduction, Canadian Global Change Program, The Royal Society of Canada, Technical Report Series No. 93-1, September 1993

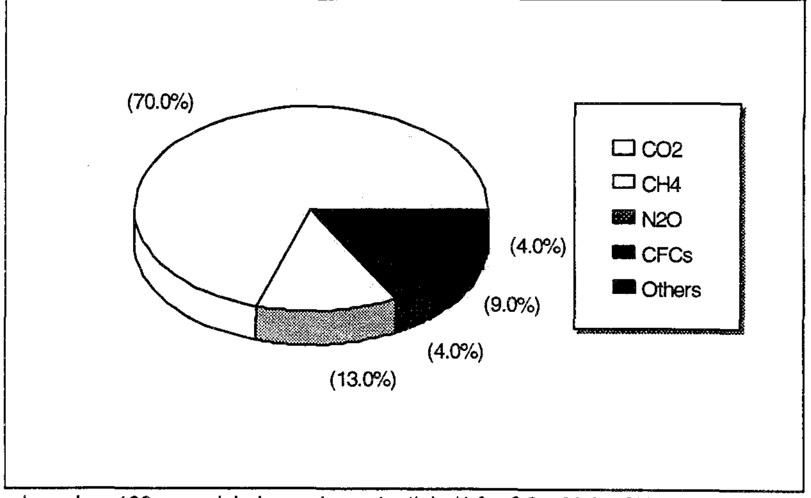
Greenhouse Gases

As noted, three greenhouse gases are of principle concern: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The indirect effects of other greenhouse gases, namely carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane hydrocarbons (NMHC) is at this time uncertain.[7] Chlorinated fluorocarbons are also identified as contributing to the direct warming of the planet.

The direct global warming potentials (GWP) of trace gases in the atmosphere, as shown in the table, measure the heat absorbing characteristics of the gas relative to carbon dioxide. The global warming potential is a time-integrated measure which accounts for both the instantaneous radiative forcing due to an instantaneous release of the gas and the lifetime of the gas.

Carbon dioxide, a trace gas in the atmosphere, varies naturally in concentration with biological activity. Human activities that affect CO_2 concentration include burning fossil fuels, harvesting, foresting, and converting land to agricultural uses. Carbon dioxide is by far the most important greenhouse gas accounting for 70% of the infrared absorption due to all greenhouse gas emissions as noted above. See Figure 5.3.

Figure 5.3
Radiative Forcing of Greenhouse Gases



- based on 100 year global warming potentials (1 for CO_2, 22 for CH_4, 270 for N_2O and 5000 for CFCs)
- page 4, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

[7] Intergovernmental Panel on Climate Change, *Climate Change 1992,* Supplementary Report to the IPCC Scientific Assessment, J.T. Houghton, B.A. Callander, and S.K. Varney (eds), prepared for the Intergovernmental Panel on Climate Change, Cambridge University Press, February 1992

Methane and nitrous oxide are important greenhouse gases that are linked to a number of anthropogenic sources. In methane's case landfills, leakage from upstream oil and gas operations and domesticated animals accounted for the bulk of methane release into the atmosphere (94% of all anthropogenic sources). Nitrous oxide emissions result from fuel combustion, industrial processes and fertilizer use (~100% of all anthropogenic sources). It appears soil emissions of nitrous oxide may be ten times larger than man-made emissions.[8] Methane and nitrous oxide emissions that result from residential sources, in particular, those targetted by this study appear small.

8 page 5, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

Table 5.1
Direct Global Warming Potentials of Trace Gases (IPCC, 1992)[1]

Trace Gas	Lifetime (years)	20 years	100 years	Indirect Effect
CO_2	-	1	1	none
CH_4	10.5	34	11	positive
N_2O	132	250	270	uncertain
CFC-11	55	4,400	3,400	negative
CFC-12	116	7,000	7,100	negative
CFC-113	110	4,400	4,500	negative
CFC-114	220	5,900	7,000	negative
CFC-115	550	5,300	7,000	negative
HCFC-22	15.8	4,100	1,600	negative
HCFC-123	1.7	330	90	negative
HCFC-124	6.9	1,500	440	negative
HFC-125	40.5	5,100	3,400	none
HFC-134a	15.6	3,100	1,200	none
HCFC-141b	10.8	1,800	580	negative
HCFC-142b	22.4	3,900	1,800	negative
HFC-143a	64.2	4,600	3,800	none
HFC-152a	1.8	520	150	none
CCl_4	47	1,800	1,300	negative
CH_3CCl_3	6.1	360	100	negative
CF_3Br	77	5,600	4,900	negative
$CHCl_3$	0.7	92	25	negative
CH_2Cl_2	0.6	54	15	negative
CO	months	-	-	positive
NMHC	days to months	-	-	positive
NO_X	days	-	-	uncertain

[1] Intergovernmental Panel on Climate Change, *Climate Change 1992,* Supplementary Report to the IPCC Scientific Assessment, J.T. Houghton, B.A. Callander, and S.K. Varney (eds), prepared for the Intergovernmental Panel on Climate Change, Cambridge University Press, February 1992

Carbon Dioxide Sources

The present atmospheric emissions in Canada of carbon dioxide are shown in Table 5.2. Emissions as shown have increased by about 2% since 1990.

Table 5.2
Fossil Fuel and Process Related Emissions[1]

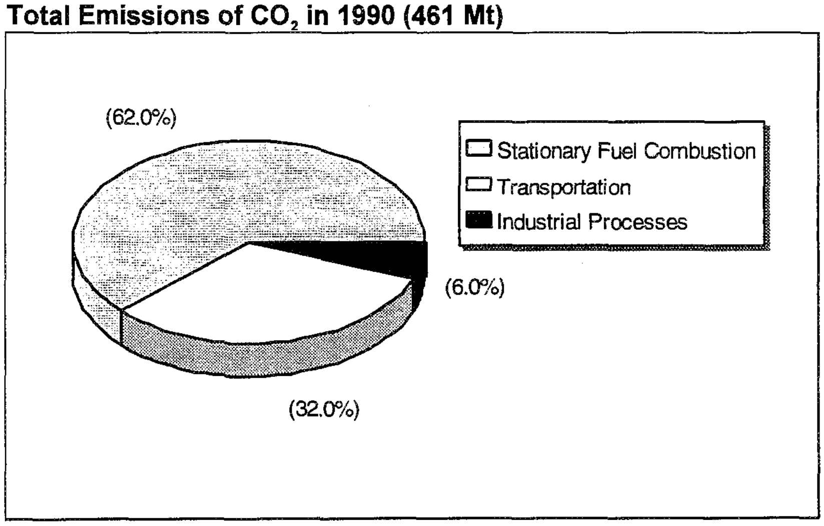
	1989	1990	1991	1992	1993
	(CO_2 Mt)	(CO_2 Mt)	(CO_2 Mt)	(CO_2 Mt)	(CO_2 Mt)
Coal	105	95	98	101	94
Natural Gas*	139	132	132	139	145
Crude Oil	230	218	207	211	215
Process	16	16	15	15	16
Totals	**490**	**461**	**452**	**466**	**470**

* These estimates include about 5 Mt from Synthetic Crude Oil Production

1 personal correspondence, A.P. Jaques, December 22, 1994

The sources of carbon dioxide emissions in Canada and in Ontario have been identified in Figure 5.4 and Table 5.3. Fossil fuel-related emissions accounted for 97% of the Canada's total anthropogenic carbon dioxide emissions with the remaining 3% from industrial processes such as cement and lime production[9].

Figure 5.4
Total Emissions of CO_2 in 1990 (461 Mt)



9 page 2, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

Table 5.3
Summary of Emissions of Carbon Dioxide (kt) in Canada (1990)[1]

	Ontario	**Canada**
Fuel Combustion Stationary Sources		
Power Generation	25,935	93,873
Residential	16,452	40,733
Commercial	8,398	23,984
Industrial	33,204	75,350
Agricultural	806	2,478
Other*	8,309	50,189
Subtotal	**93,105**	**286,607**
Transportation Sources**		
Subtotal	**46,784**	**144,931**
Industrial Processes***		
Subtotal	**7,461**	**28,856**
TOTALS	**147,351**	**460,394**

* Public Administration, Steam Generation, Refined Products, Own Use: Natural Gas/RPPs/Coal, Pipelines

** **Gasoline:** Automobiles, Light-duty trucks, Heavy-duty trucks, Motorcycles;
Diesel: Light-duty trucks, Heavy-duty trucks, Other;
Road: Natural Gs Motor Vehicles, Propane Motor Vehicles;
Off-Road: Rail, Marine, Aircraft, Off-road gas

*** Cement Production, Lime Production, Stripped Natural Gas, Non-energy Use

Note: Totals may not add exactly, due to rounding.

[1] derived from page xix, A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990,* Report EPS 5/AP/4, Environment Canada, Ottawa, December 1992

Table 5.4 shows Ontario's fossil fuel-related CO_2 emissions for 1990 by fuel type and end use including electricity generation. In 1990 in Ontario, the residential sector consumed approximately 35% of electricity generated (see Figure 5.5). The residential and agricultural fossil fuel-related emissions therefore accounted for 19% of total carbon dioxide emissions in Ontario including electricity generation attributable to the sector.

Figure 5.5
Ontario's Energy Consumption by Sector (1990)

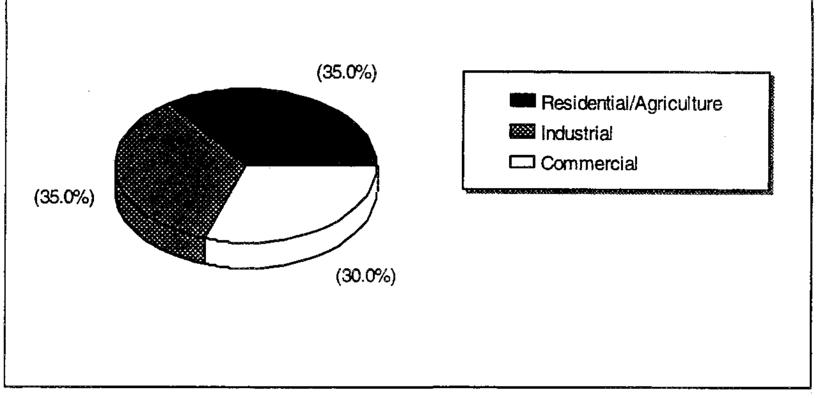


Table 5.4
Ontario's Fossil Fuel-Related CO_2 Emissions in 1990 (kilotonnes)[1]

	Oil	Natural Gas	Liquid Petroleum Gases	Coal	Total
Residential and Agriculture	5,297	12,958	306	0	18,561
Commercial	2,210	7,400	299	0	9,909
Industrial	10,323	19,155	567	13,015	43,060
Transportation	42,129	39	646	0	42,814
Electricity Generation	1,059	420	0	24,623	26,102
Non-Energy	2,500	693	330	290	3,813
Total	63,318	40,665	2,148	38,128	144,259

1 Economic and Financial Analysis Branch, Energy Sector, Natural Resources Canada, *qtd.* page 11, Canadian Institute for Environmental Law and Policy, *Carbon Dioxide Reduction Options for Ontario: A Discussion Paper*, Toronto, August 1994

Table 5.5
End Use Demand by Fuel and Sector - Ontario (1990)[1]

	Electricity	Percentage
Residential	169.4	35%
Commercial	144.3	30%
Industrial	169.3	35%
Total	484.4	100%

1 page 354, National Energy Board, Canadian Energy: Supply and Demand 1990-2010, National Energy Board of Canada, June 1991

Table 5.6
Ontario's Residential and Agricultural Fossil Fuel-Related CO_2 Emissions in 1990 (kilotonnes)[1]

	Oil	Natural Gas	Liquid Petroleum Gases	Coal	Total
Fuel Use	5,297	12,958	306	0	18,561
Electricity Generation	371	147	0	8,618	9,136
Total	5,668	13,105	306	8,618	27,697

1 Economic and Financial Analysis Branch, Energy Sector, Natural Resources Canada, *qtd.* page 11, Canadian Institute for Environmental Law and Policy, *Carbon Dioxide Reduction Options for Ontario: A Discussion Paper*, Toronto, August 1994

Air Pollutants

Air pollutants commonly emitted from energy production include particulates (TSP, total suspended particulates), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x) and volatile organic compounds (VOCs). These pollutants can have a serious impact on human health and the environment. They have also been included as part of the emissions analysis of this study.

Ash and Spent Nuclear Fuel

The ash and spent nuclear fuel associated with electricity generation has been calculated and assigned to the space heating of new homes. These are presented on the pages that follow.

Environmental Impact Of Residential Space Heating

Residential Space Heating

The residential sources of emissions that have been examined are confined to residential space heating equipment. The equipment provides space heating from electricity, natural gas, oil or propane combustion. The emissions associated with space heating appliances have been estimated based on the energy consumed to heat the archetype houses.

The space heating consumption was simulated and presented in Section 3 of this report for the six house types located in Toronto and Sault Ste Marie. The space heating consumption for each building was used to derive emissions.

Emissions analysis

The analysis of emission is founded on emissions load factors ascribed to residential heating equipment. Data supplied by Consumers Gas Limited from Tellus Institute were used to calculate emissions for the propane, oil, natural gas and wood emissions. The data was corroborated using emission factors from Environment Canada and The U.S. Environmental Protection Agency (EPA).

Data for electricity was provided by Ontario Hydro. Emissions from the generation of electricity depends on a number of variables. The most significant among these is the mix of generation; that is, what fraction of the generation is supplied by hydro, nuclear, coal, oil or gas. The emissions from the system depend on the time of day and time of year as well as the geographic location.

The emissions for electricity that were used are based on total system emission factors at the margin. Emissions at the margin are used since new buildings represent marginal load. Using average system emission factors would be inappropriate in this situation. The electricity emission factors that were used assume on an annual basis that 85% of the load is supplied by fossil means (primarily coal) with the remainder primarily from nuclear.

Table 5.7 summarizes the emission factors used in the study. Note that wood emissions factors have been presented for information only. The emissions associated with residential wood heating have not been quantified.

Table 5.7
Emission Factors (kg/GJ in) for End Use Devices[1]

	ELECTRICITY	PROPANE	OIL	NATURAL GAS	WOOD
CO2	2.70E+02	5.64E+01	7.3E+01	5.1E+01	7.90E+01
NOx	4.80E-01	6.39E-02	2.9E-02	2.8E-02	7.80E-02
CH4	0.00E+00	0.00E+00	5E-03	1E-03	3.50E-02
SOx	1.30E+00	6.24E-05	9.4E-02	4E-04	1.10E-02
TSP	1.50E-01	1.88E-03	8E-03	6E-03	1.10E+00
CO	0.00E+00	5.64E-03	1.3E-02	7E-03	6.50E+00
VOC	3.00E-03	2.26E-03	8E-03	3E-03	2.30E+00
ASH	1.3E+01				
SPENT NUCLEAR FUEL	7.3E-04				

[1] derived from data supplied by Consumers Gas Limited from Tellus Institute and from data supplied by Ontario Hydro.

Monetization

The residential emissions associated with space heating equipment were calculated using the emission factors presented above for all six house archetypes in both degree-day zones for both OBC and NECH levels.

An attempt has been made to monetize the calculated emissions using externality valuations as presented in Table 5.8. This table is the result of a review of literature together with discussions with individuals representing Ontario utilities, consumer and environmental groups.

Tables 5.9 to 5.12 present the emissions associated with the space heating of selected buildings. The total space heating energy consumption is presented as is the total yearly cost (also represented in present value terms) associated with emissions that result from the energy consumption. The tables also present the total cost associated with each emission.

The yearly costs associated with the emissions has been calculated using the valuations as discussed above. These costs have been presented in present value terms using the NECH economic assumptions; namely, across 30 years at a 6% real discount rate. A complete listing for all of the buildings for both OBC and NECH levels is found in Appendix 4 of this report.

Table 5.8
Externality Valuations for Simulations ($/tonne)

	Simulated	Range	
		low	high
CO2	$40	$10	$60
NOx	$188	$188	$15,000
CH4	$385	$110	$660
SOx	$734	$734	$4,800
TSP	$15	$15	$16,400
CO	$1,400	$1,400	$1,400
VOC	$5,250	$3,000	$7,500

Table 5.9
Space Heating Emissions Production (kg/year)
Large Two Storey, OBC, Zone 1, all electric

HOUSE ID		ELECTRICITY (Energy,MJ) (Emissions, kg)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL (kg)	YEARLY COST	PRESENT VALUE
TTLOEEH	Energy	31,228.92	0	0	0	31,228.92	$370	$2,128
	CO2	8,431.81	0	0	0	8,431.81	$337	
	NOx	14.99	0	0	0	14.99	$3	
	CH4	0	0	0	0	0	$0	
	SOx	40.6	0	0	0	40.6	$30	
	TSP	4.68	0	0	0	4.68	$0	
	CO	0	0	0	0	0	$0	
	VOC	0.09	0	0	0	0.09	$0	

Table 5.10
Space Heating Emissions Production (kg/year)
Large Two Storey, OBC, Zone 1, mid efficiency gas

HOUSE ID		ELECTRICITY (Energy,MJ) (Emissions, kg)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	YEARLY COST	PRESENT VALUE
TTLOMGF	Energy	4,642.92	0	0	60,527	65,169.92	$180	$1,036
	CO2	1,253.59	0	0	3,086.88	4,340.47	$174	
	NOx	2.23	0	0	1.7	3.92	$1	
	CH4	0	0	0	0.06	0.06	$0	
	SOx	6.04	0	0	0.02	6.06	$4	
	TSP	0.7	0	0	0.36	1.06	$0	
	CO	0	0	0	0.42	0.42	$1	
	VOC	0.01	0	0	0.18	0.2	$1	

Table 5.11
Space Heating Emissions Production (kg/year)
Large Two Storey, OBC, Zone 2, all electric

HOUSE ID		ELECTRICITY (Energy,MJ) (Emissions, kg)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	YEARLY COST	PRESENT VALUE
STLOEEH	Energy	44,533.8	0	0	0	44,533.8	$528	$3,034
	CO2	12,024.1	0	0	0	12,024.1	$481	
	NOx	21.4	0	0	0	21.4	$4	
	CH4	0	0	0	0	0	$0	
	SOx	57.9	0	0	0	57.9	$42	
	TSP	6.7	0	0	0	6.7	$0	
	CO	0	0	0	0	0	$0	
	VOC	0.1	0	0	0	0.1	$1	

Table 5.12
Space Heating Emissions Production (kg/year)
Large Two Storey, OBC, Zone 2, mid efficiency gas

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	YEARLY COST	PRESENT VALUE
STLOMGF	Energy	4,964.4	0	0	75,265	80,229.4	$215	$1,234
	CO2	1,340.4	0	0	3,838.5	5,178.9	$207	
	NOx	2.4	0	0	2.1	4.5	$1	
	CH4	0	0	0	0.1	0.1	$0	
	SOx	6.5	0	0	0	6.5	$5	
	TSP	0.7	0	0	0.5	1.2	$0	
	CO	0	0	0	0.5	0.5	$1	
	VOC	0	0	0	0.2	0.2	$1	

Table 5.13 summarizes the calculated externality valuations for all houses in both Toronto and Sault Ste. Marie for both the OBC and the NECH buildings. Carbon dioxide emissions assume by far the largest fraction of the environmental costs as measured by this study. Using value of $40/tonne of CO_2 results in an environmental cost to the homeowner of about $180 year using as an example a 2100 square foot house in Toronto that uses a mid-efficiency gas furnace. This annual cost varies with the building's energy consumption and the heating fuel. Across the life (assumed to be 30 years) of the building in this example, the environmental costs associated with these emissions is approximately $ 1000.00. That same house heated with electricity has an environmental externality associated with it of approximately $ 2000.00. Refer to Appendix 4 for a complete listing of emissions and costs for all buildings simulated.

For proponents of a cost of control strategy or a carbon tax, these values represent the approximate costs new home purchasers would experience. Owners of existing buildings could expect a level somewhat higher, given these buildings are generally less energy efficient than new buildings.

Table 5.13
Present Value of Emissions Associated with Space Heating for Typical Houses in Ontario

OBC ZONE 1		NECH ZONE A		OBC ZONE 2		NECH ZONE B	
House ID	Present Value	House ID	Present Value	House ID	Present Value	House ID	Present Value
TTLOEEH	$2,128	TTLNEEH	$2,042	STLOEEH	$3,034	STLNEEH	$2,790
TTLOASH	$1,246	TTLNASH	$1,453	STLOASH	$1,842	STLNASH	$1,825
TTLOGSH	$932	TTLNGSF	$1,341	STLOGSH	$1,257	STLNGSH	$1,484
TTLOMOF	$1,379	TTLNMOH	$1,079	STLOMOF	$1,660	STLNMOH	$1,265
TTLOMPF	$1,112	TTLNMPH	$883	STLOMPF	$1,327	STLNMPH	$1,027
TTLOMGF	$1,036	TTLNMGF	$1,003	STLOMGF	$1,234	STLNMGH	$1,092
TTLOHGF	$940	TTLNHGF	$911	STLOHGF	$1,114	STLNHGH	$1,109
TTSOEEH	$1,416	TTSNEEH	$1,360	STSOEEH	$2,042	STSNEEH	$1,878
TTSOASH	$888	TTSNASH	$1,041	STSOASH	$1,274	STSNASH	$1,268
TTSOGSH	$687	TTSNGSF	$1,088	STSOGSH	$913	STSNGSH	$1,104
TTSOMOF	$1,075	TTSNMOH	$797	STSOMOF	$1,277	STSNMOH	$912
TTSOMPF	$883	TTSNMPH	$669	STSOMPF	$1,040	STSNMPH	$760
TTSOMGF	$829	TTSNMGF	$825	STSOMGF	$973	STSNMGH	$827
TTSOHGF	$759	TTSNHGF	$757	STSOHGF	$887	STSNHGH	$759
TBSOEEH	$1,815	TBSNEEH	$1,721	SBSOEEH	$2,723	SBSNEEH	$2,482
TBSOASH	$1,079	TBSNASH	$1,197	SBSOASH	$1,630	SBSNASH	$1,590
TBSOGSH	$975	TBSNGSF	$1,241	SBSOGSH	$1,155	SBSNGSH	$1,226
TBSOMOF	$1,219	TBSNMOH	$912	SBSOMOF	$1,452	SBSNMOH	$1,136
TBSOMPF	$992	TBSNMPH	$757	SBSOMPF	$1,173	SBSNMPH	$930
TBSOMGF	$929	TBSNMGF	$931	SBSOMGF	$1,094	SBSNMGH	$912
TBSOHGF	$847	TBSNHGF	$850	SBSOHGF	$994	SBSNHGH	$834
TSDOEEH	$1,340	TSDNEEH	$1,288	SSDOEEH	$1,920	SSDNEEH	$1,770
TSDOASH	$850	TSDNASH	$966	SSDOASH	$1,219	SSDNASH	$1,205
TSDOGSH	$661	TSDNGSF	$1,041	SSDOGSH	$883	SSDNGSH	$1,032
TSDOMOF	$1,021	TSDNMOH	$746	SSDOMOF	$1,224	SSDNMOH	$876
TSDOMPF	$843	TSDNMPH	$631	SSDOMPF	$1,000	SSDNMPH	$733
TSDOMGF	$793	TSDNMGF	$795	SSDOMGF	$937	SSDNMGH	$779
TSDOHGF	$729	TSDNHGF	$731	SSDOHGF	$857	SSDNHGH	$731
TREOEEH	$876	TRENEEH	$839	SREOEEH	$1,270	SRENEEH	$1,164
TREOASH	$617	TRENASH	$702	SREOASH	$866	SRENASH	$859
TREOGSH	$494	TRENGSF	$857	SREOGSH	$645	SRENGSH	$794
TREOMOF	$833	TRENMOH	$555	SREOMOF	$987	SRENMOH	$642
TREOMPF	$700	TRENMPH	$485	SREOMPF	$820	SRENMPH	$555
TREOMGF	$662	TRENMGF	$666	SREOMGF	$774	SRENMGH	$619
TREOHGF	$614	TRENHGF	$617	SREOHGF	$714	SRENHGH	$577
TRIOEEH	$545	TRINEEH	$517	SRIOEEH	$815	SRINEEH	$741
TRIOASH	$442	TRINASH	$476	SRIOASH	$620	SRINASH	$607
TRIOGSH	$376	TRINGSF	$641	SRIOGSH	$483	SRINGSH	$675
TRIOMOF	$626	TRINMOH	$404	SRIOMOF	$747	SRINMOH	$466
TRIOMPF	$541	TRINMPH	$368	SRIOMPF	$637	SRINMPH	$420
TRIOMGF	$517	TRINMGF	$516	SRIOMGF	$606	SRINMGH	$461
TRIOHGF	$487	TRINHGF	$485	SRIOHGF	$567	SRINHGH	$438

Ash and Spent Fuel

Table 5.14 presents a summary of the ash and nuclear fuel production associated with residential space heating in new Ontario houses. These values are based on the emission factors provided by Ontario Hydro. The calculated emissions vary according to the fuel used to heat the building with the highest emissions for electrically heated houses and the lowest for gas heated houses.

The data reveal insignificant differences between ash and fuel production for OBC and NECH houses in both degree-day zones in Ontario.

Table 5.14
Ash and Spent Nuclear Fuel Associated with Residential Space Heating (kg/year)

	ZONE 1				ZONE 2			
	OBC		NECH		OBC		NECH	
	ASH	NUCLEAR FUEL	ASH	NUCLEAR FUEL	ASH	NUCLEAR FUEL	ASH	NUCLEAR FUEL
Average	112	0.006	122	0.007	148	0.008	145	0.008
maximum	406	0.023	390	0.022	579	0.033	532	0.03
minimum	55	0.003	50	0.003	59	0.003	54	0.003

Discussion Of Results

A review of the simulated emissions of residential space heating processes reveals that for the majority of new houses in Ontario, moving to the National Energy Code for Housing levels from those currently of the Ontario Building Code provides insignificant environmental benefits.

The NECH provides limited environmental benefits over the OBC for oil and propane-heated buildings.

6. Review of NECH and OBC Technical Issues

This chapter in the report is intended to address some of the technical issues arising from NECH requirements, particularly where these differed significantly from those found presently within the OBC.

The issues which were identifed for examination are as follows:

- Exterior lighting controls;
- Programmable setback thermostats;
- Requirements for heat pumps;
- Energy source classification for wood;
- Window and glazing requirements; and
- Potential impacts of trade-offs.

Each of these issues is dealt with individually in the sections which follow.

Exterior Lighting Controls For Individual Dwelling Units

The requirements of the NECH for exterior lighting controls for individual dwelling units may be found under Article 4.2.2.2. This articles states that:

> (1) Exterior lighting units serving individual *dwelling units* shall be controlled by
>
> (a) a photocell, and
> (b) a timer or motion detector.

The primary issue related to the requirements of this article involves their cost effectiveness on the basis of life cycle cost. Discussions with NRC staff and committee members indicated that no explicit economic analysis of this requirement was carried out. This deviation from the approach taken in much of the NECH methodology was therefore tabled for further analysis. Enforcement issues associated with exterior lighting controls are discussed separately in Chapter 7.

Before proceeding with the discussion, it should be noted that a number of assumptions were made in the analysis conducted herein.

1. A critical assumption relates to whether exterior lighting controls are primarily energy, or health and safety related. The benefit of crime reduction associated with automatic exterior lighting controls was not factored into this analysis, however, it may represent the primary rationale for this requirement, and possibly should come under the Building Code rather than the Energy Code. A strong argument for this alternative emphasis is that the level of security provided by automatic exterior lighting controls could not be compromised under current provisions for equivalent performance in terms of energy efficiency.

2. The analysis assumed add-on devices, and discarded the use of spotlight fixtures converted to motion detector sensors. This option involves removing the spotlights, plugging the octagon box spotlight outlets, and wiring between the exterior lighting fixture and the detector sensor. While this option is the least costly to purchase, the labour associated with conversion, and the intrusiveness of the sensor, compared with add-on types, suggest that it would not represent mainstream practice. Add-on devices do not restrict the consumer's choice of fixture - an approach consistent with that taken to fuel choices in the NECH methodology.

3. A single photocell controlling the entire outdoor electrical circuit was ruled out, technical feasibility aside, since outdoor receptacles are usually connected to this circuit, and their operation would be restricted in daylight hours. The typical control device combinations were assumed as being either a photocell itself, a photocell and a timer, or a photocell and a motion detector. Note that the latter combination is generally integral to add-on motion detector sensor devices.

4. The cost of these controls was taken as the retail price plus applicable taxes (11.5% net PST/GST). A blended average price was used, assuming an equal number of stand-alone photocells, photocells with digital timers, and photocells integral to motion detector sensors. No cost was assigned to the additional labour associated with installation of these devices, since only a handful are typically installed, and the incremental labour is relatively insignificant in new construction. No account was given to the useful service life of these devices, and hence replacement costs during the 25-year life cycle study period were not considered.

The first step in the analysis involved arriving at the capital cost of these control devices. A small survey of major lighting and electrical suppliers in the Toronto metropolitan area was conducted, and the results are compiled in Table 6.1. A net 11.5% PST/GST was added to the average price to arrive at the cost for each device. The blended average cost was derived by summing the average photocell cost, the average cost of a photocell and a timer device, and the average cost of the motion detector with integral photocell, then averaging this sum. It may be expected that this blended average cost per fixture controlled will decrease over time, as have most consumer electronic products. Suppliers reported that the selection of add-on and integral devices is increasing dramatically due to considerations of home safety, but that most devices and fixtures are manufactured or distributed from the U.S. Given the decline in the value of the Canadian dollar, most of these remain quite expensive, hence they represent special orders which are not yet readily available over the counter. In this analysis, a capital cost to the consumer of $54.93 per fixture controlled was used.

Table 6.1
Residential Lighting Controls Capital Cost Analysis

SUPPLIER	CONTROL DEVICE AND RETAIL PRICE					
	PHOTOCELL		TIMER		MOTION DET.	
RAYMAR ELECTRICAL SALES						
(905)889-2862	$16.50		$36.00		$65.00	
WIRING MART						
(416)752-7360	$30.00		$38.00		$70.00	
SESCO LTD.						
(416)745-9292	20		35		75	
JOMAR ELECTRIC						
(416)536-2194	26		25		80	
GERRIE ELECTRIC						
(905)845-2891	20		30		60	
AVERAGE COST PER DEVICE	$22.50		$32.80		$70.00	
with 11.5% NET PST/GST	$25.09		$36.57		$78.05	**$54.93**
The costs quoted above do not include labour associated with installing these lighting control devices. For the purposes of this study, it has been assumed that electrical contractors would absorb this incidental increase in installation time.						BLENDED AVERAGE COST

A breakeven analysis was subsequently performed, due to the absence of data indicating the energy saving associated with each of these control devices, or control devices of this kind in general. The breakeven analysis has been performed by assuming 1, 2 or 3 exterior lighting fixture controls, and then determining the daily energy savings needed to breakeven with the added capital cost of the controls. The daily savings needed may, at this point, only be compared to a typical daily consumption figure reported verbally by Tom Hamlin of NRCan of 1 kWh, based on preliminary Flair Enerdemo project monitoring. An alternative means of reckoning the plausibility of attaining the required level of savings is to compare how many fewer hours per day a typical fixture would have to operate. The breakeven analysis presented in Table 6.2 is intended to enable these simplified means of assessing cost effectiveness to be performed.

Table 6.2 **Lighting Control Breakeven Analysis**	
SAVINGS (kWh)/day X 365 days/year X OCF ($/kWh) = Cost of Control Device(s)	
Given a 25-year Operating Cost Factor for Electricity = 1.24	
BREAKEVEN	kWh/day
Assuming 1 control device	0.12
Assuming 2 control devices	0.24
Assuming 3 control devices	0.36
The simplified analysis presented above does not account for the useful service life of lighting control devices over the life cycle study period.	

Assuming that a typical house uses 1 kWh per day for exterior lighting, the daily saving above can be conveniently converted into a percentage reduction. While the breakeven daily savings are simply linear in the above figure, it is unlikely that outdoor lighting energy consumption increases linearly with the number of fixtures installed. Casual observations of outdoor lighting in typical new neighbourhoods tend to indicate that primarily 1, and at the most 2 lights are used over any significant part of the evening. Again, statistical data are lacking, however, the significance of the relationship between the number of fixtures installed, their efficacy, and the outdoor lighting energy consumed is critical.

For example, where only 1 light is installed, only 120 Watt.hours savings are needed each day to breakeven. Assuming a 60 W incandescent lamp, a 2 hour reduction per day over manually controlled exterior lighting is required to breakeven. When a compact fluorescent lamp is used, this typically translates into a 6 hour reduction per day. The efficacy of the exterior fixture's lamping is a critical variable. In the case where 3 fixtures are installed, but only 1 accounts for most of the consumption, between 6 and 18 hours of reduced operating time is required. With 2 fixtures accounting for most of the consumption, between 3 and 9 hours of reduced operating time for each fixture is required. Clearly, depending on the number of exterior lighting fixtures installed, and their efficacy, there are many cases where given a 100% reduction in operating time, the controls would not be cost effective. This possibility leads to a broader discussion of the issues involved.

Because facts and figures were not available to carry out a rigorous life cycle cost effectiveness analysis on outdoor lighting requirements, the scope and assumptions of the breakeven analysis undertaken here were greatly simplified. Assuming that an approach congruent with that taken for the building envelope under the NECH was undertaken, consideration would have to be given to the following items:

Photocell Controls

Photocell controls are generally the least expensive means of controlling outdoor lighting. They are generally recommended for use with a timer, otherwise occupants must switch them off manually when retiring at night, assuming this is normally done in a given dwelling, and remember to switch them on the next day. A low wattage, high efficacy security light, intended to stay on the whole evening, represents an example of how the control may be used without a timer device. The difference between electrical consumption for photocell versus manual controls on exterior lighting was not provided or established in the simplified analysis undertaken here, instead the amount of daily saving was established to breakeven. This saving and the typical combination of photocell controls with other types would have to be confirmed in the field to properly assess photocell controls. In principle, photocells are desirable in promoting energy efficiency in that they avoid the accidental use of lighting during daylight hours.

Timer Controls

Timers are more costly than photocell controls, however, they permit flexible programming of the operating schedule. Sales figures were not available to determine the preference between timers and motion detectors in new housing, but with exception to night long security lighting, it is reasonable to assume that this device would be generally installed with photocell controls. As with photocell controls, differences between timer and manual controls' electrical consumption are unknown. The timer schedule applied by occupants of the dwelling is a strong determinant of electrical consumption, and it is possible that peak demand may be impacted in demographically homogeneous developments. Peak demand impacts and consumer savings associated with timer controls should be quantified to permit a more rigorous assessment.

Motion Detector Controls

Motion detectors represent the most costly control option as an add-on device, but represent the least costly choice if the ubiquitous two-socket spotlight fixture is purchased. This control has the advantage of providing security lighting on demand, however, it is not recommended with high efficacy lamping, such as low pressure sodium, due to the slow warm-up time for this type of lamp. In this study, it was not possible to determine the typical number installed per dwelling, and the market share of motion detectors in new housing versus other control devices (manufacturers do not provide sales figures, and the split between existing and new home installations is not differentiated in their sales figures, at any rate). Motion detectors typically permit the setting of operating cycle time after activation, and this may significantly impact the energy savings for this device. Again, field data are required to enable a more detailed assessment of this control's cost effectiveness.

Synopsis
Based on energy savings, the cost effectiveness of exterior lighting controls required under the NECH for individual dwelling units cannot be fully ascertained at this point. The benefits in improved security may be easier to obtain than the extensive information required to conduct as rigorous an analysis as was performed for the building envelope by the NECH. This suggests that with exception to photocells, which avoid wasting lighting energy during daylight hours, the remaining requirements may prove more appropriate under the Building Code. In view of the issues raised in this analysis the following recommendations may be considered:

1. Field data should be obtained which provide an appropriate measure of statistical confidence in the actual energy savings associated with exterior lighting controls.
2. Real costs to consumers should be obtained from the building industry for the provision of these controls, as well as an indication of how many of these are typically provided in new housing already.
3. The useful service life of these controls should be factored into a life cycle assessment of their cost effectiveness.
4. Strong consideration should be given to differentiating between exterior lighting control requirements suited to the intent of the Energy Code versus that of the Building Code.
5. The proliferation of home automation systems, the adoption of hybrid controls as standard features integral to outdoor lighting fixtures, and consumers' tendency to provide such controls motivated by security rather than energy concerns, may practically eliminate the need for enforcing this requirement.

A final perspective on the requirements for exterior lighting concerns the spirit in which these were included in the NECH. Normally, some form of demonstrable cost effectiveness criteria are established and then used to assess the performance associated with a new code requirement and the status quo. This was not the case for exterior lighting, and some consideration should be given to the potential loss of credibility for the codes process in the eyes of the building industry should this approach become widespread.

Programmable Setback Thermostats

Under Article 5.2.9.2 of the NECH, the following requirement for the provision of programmable setback thermostats was initially proposed:

> (1) A heating system intended to serve an entire dwelling unit as a single controlled *zone* shall be equipped with an automatic programmable thermostat which permits the space temperature to be set back in accordance with a time schedule that can be programmed by the occupant.

Recent discussions with NRC staff indicate that this requirement will be revised such that programmable setback thermostats will be only be required for central heating systems in dwellings (overruling the published Appendix Note). Both electric resistance unitary heaters (e.g., baseboard radiators) and multi-zone hydronic systems would be exempted for reasons of cost, and in some cases technical complexity, or unavailability of components.

When forced air heating systems also provide cooling, the requirements for thermostatic controls under 5.2.9.1.(5) and (6) also apply. These call for a minimum 1.5 Celsius degree deadband between heating and cooling setpoints, as well as their being uncoupled. The systems affected by these requirements are forced air heating systems with central air conditioning, air source and ground source heat pumps.

A review of proceedings and NRC staff associated with the development of the programmable setback thermostat requirement indicates that no analysis of cost effectiveness was performed or considered. A number of issues have since been raised regarding the assumptions and implications behind this requirement.

- Information about the rate of heat decay in buildings constructed to NECH, or for that matter OBC requirements, is not available. It is significantly influenced by ventilation rates and heat recovery effectiveness. It is not clear whether there would be a sufficient drop in temperature (ΔT effect) to economically justify setback. If the ΔT effect is small, then savings will be small. It also appears that deep set-back thermostat settings may have health implications that become far more important than energy savings.
- If the rate of heat decay is significant, then depending on the thermostatic control's recovery strategy, as much

energy as was saved may have to be generated to establish the same mean radiant field within the dwelling, assuming this parameter is critical to occupant comfort.

- The manner in which setback thermostats are used is not well understood . Discussions with Consumers Gas indicated that many people without programmable thermostats practice manual setback, while many owners of programmable thermostats only use the manual control functions. The setback temperature setpoints and schedules also vary. Some households setback during the day when occupants are away at work and school, opting for warmer temperatures in the evenings, while others select the sleeping hours for setback. Generally, occupants that setback heating, also setback cooling when it is installed. Unlike insulation, setback thermostats rely on user behaviour for the realization of their cost effectiveness, and the utilization efficiency of setback thermostats across new housing stock remains largely unknown.
- During the builder roundtable conducted in 1991 with OHBA prior to the development of the latest OBC thermal insulation requirements, builders from Zone 2 reported that setback thermostats were associated with window condensation problems (the lowered air temperature reduces the window surface temperature, thereby increasing condensation potential). The degree to which the higher performance windows now required under the NECH alleviate this condition may be roughly estimated using the temperature index for the glazing, however the edge seal temperature condition will provide for a more accurate indication of condensation potential. The case where the curtains are drawn was reported as being most critical, hence this should also be examined. Technical analysis of these builder concerns was outside the scope of this study.
- Setback thermostats have been reported to cause resistance heater operation in ground source heat pumps during the recovery period, significantly increasing operating costs. This may not be the case for all ground source technology, as some manufacturers report that with high end models, more sophisticated controls are available.
- The peak demand implications of setback thermostats may be significant in the cases of electricity and natural gas. In the case of electricity, the impact of simultaneous activation of setback thermostats can be significant on

peak electrical demand in many Ontario municipalities. An extremely critical example involves remote communities served by a limited capacity transmission line, and relying largely on electricity for space heating. Peak demand problems may be encountered, especially if the nature of the community's schedules is monotonic (e.g., primary industry employing the majority of the community, with only one shift starting at the same time for all of its employees). In the case of natural gas, the primary concern revolves around the sizing of street mains where the least flexibility in pressure compensation to meet increases in peak demand is normally available. A general concern for both energy sources relates to the diffusion of Code requirements throughout the existing housing stock, seeing that consumers in general view new Code requirements as representing better practice.

- The cost of setback thermostats where central air conditioning or air source heat pumps are installed is significant. (Note that setback thermostats normally accompany ground source heat pumps as standard equipment.)
- Programming of these devices is generally not straightforward, often leading to occupant frustration (an article in the popular press cited programmable thermostats as the perfect present for someone you dislike). This implication of setback thermostat operation is generally not appreciated by technically sophisticated Code developers.

Given these concerns regarding both the assumptions and implications behind the setback thermostat requirements of the NECH, there are essentially two means by which their cost effectiveness may be determined:

1. By performing a breakeven analysis to determine the annual energy saving needed to offset the additional investment; and
2. By comparing this investment with any alternatives to see which offers a better return.

Only the first means is explored in this study using a methodology similar to that employed for exterior lighting. The second means involves a form of value engineering where all energy Code requirements would be re-assessed according to some appropriate criteria.

Table 6.3
Residential Thermostatic Controls Capital Cost Analysis

CONTROL MODE(S)	CONTROL DEVICE AND RETAIL PRICE				AVERAGE PRICE AND COST DIFFERENCE BY CONTROL MODE(S)	
	MANUAL		SETBACK			
	MODEL	PRICE	MODEL	PRICE	PRICE	COST
HEATING	T822D	$26.00	T8090A	$142.00	$106.00	$118.19
	T86A	$46.00				
HEAT/COOL	T834C	$41.00	T8603	$248.00	$237.00	$264.26
	T87F	$51.00	T8621A	$318.00		
HEAT PUMP	T874A	$121.00	T8611G	$371.00	$250.00	$278.75

This analysis was limited to a single manufacturer's controls (Honeywell), and suggested retail prices were obtained from a Canada wide wholesale distributor of heating equipment to contractors (EMCO Wholesale Heating Supplies), as of December 1994.

Table 6.4
Setback Thermostat Breakeven Analysis (MJ/ Year Savings)

BREAKEVEN: SAVINGS (MJ)/year X OCF* ($/MJ)
= Incremental Cost of Programmable Setback Thermostat

Given the following 30-year Operating Cost Factors:

Electricity	$0.36
Natural Gas	$0.095
Oil	$0.158
Propane	$0.220

MODE(S)	ELEC	NATGAS	OIL	PROPANE
HEATING	328	1,247	748	537
HEAT/COOL	734	2,782	1,673	1,201
HEAT PUMP	774	N/A	N/A	N/A

* See Chapter 4 for discussion of Operating Cost Factor (OCF).
The simplified analysis presented above does not account for the useful service life of programmable setback thermostats over the life cycle study period.

Based on the capital costs in Table 6.3 and the breakeven analysis in Table 6.4, relatively small reductions in annual energy consumption render the investment in setback thermostats cost effective. For electricity, only 328 MJ/year savings by a heating setback thermostat is needed to breakeven. However, the key questions which remain to be answered are:

- Will this average reduction in energy be realized across a population of new homes having these devices installed?
- What are the defect and system related implications of setback thermostats?

NECH Heat Pump Requirements

The most critical issue in relation to requirements for heat pumps under the NECH relates to the difference between the minimum efficiencies required under 5.2.11 Equipment Efficiencies, and those used to develop the cost effective levels of thermal insulation.

In the former case, the minimum required efficiencies represent the low end of the manufacturers' product lines. When these units are used, their seasonal coefficient of performance (COP) is much lower than the 2.0 and 3.0 used for air source and ground source heat pumps respectively, in the NECH analysis. Depending on the size and installation of the unit in question, actual seasonal COPs may be as low as 1.4 and 2.2 for minimum efficiency air source and ground source heat pumps, respectively. As well, air source heat pump COPs vary considerably within each zone depending on local climate.

Assuming that the performance used to establish cost effectiveness was enforced in the field, rather than the minimum required efficiencies, the increased cost over current practice ranges between $800 and $1100, depending on the manufacturer. This difference is built into the capital costs used in this study, but since the higher capital cost was factored into both the OBC and NECH analyses, it is not an apparent impact of adopting this requirement according to the interpretation noted above. If this interpretation is not applied, then further analysis is required to determine the cost effective levels of thermal insulation corresponding to minimum efficiency equipment.

A less critical issue involves control requirements for heat pumps. Requirements for heat pump controls in the NECH may be found in Section 5.2 Mandatory Provisions.

5.2.9.4 Heat Pump Controls

(1) Heat pumps equipped with supplementary heaters shall incorporate controls to prevent supplementary heater operation when the heating load can be met by the heat pump alone, except during defrost cycles.

(2) Heat pumps shall be equipped with setback controls that provide temporary suppression of electrical backup or adaptive anticipation of the recovery point in order to prevent the unit from resorting to supplementary heat at time of recovery.

Appendix Note: Several techniques of achieving this exist: separate exterior temperature sensor; gradual raising of the control point; controls that learn when to start recovery from previous experience.

These requirements apply equally to air source and ground source heat pumps, however, due to the relatively constant capacity of ground source heat pumps compared with that of air source heat pumps, the discussion which follows focuses on the latter type of equipment.

A survey of manufacturers was conducted to determine the technical impacts of the requirements. It was determined that the requirements for Sentence (1) are entirely within the capability of virtually all heat pump equipment currently manufactured and sold. The proper setting of the balance point is essential during installation of the unit, and if not set to this mode, the requirement may be violated. There is therefore an enforcement issue related to ensuring this requirement is met in the field.

The requirements under Sentence (2) are not completely within the grasp of the industry. Recovery from setback was noted as nearly always triggering supplementary heating in all units. The use of an exterior temperature sensor to control the staging of supplementary heating can mitigate, but not completely eliminate supplementary heating during recovery. The use of thermostats which incorporate either a floating control point during recovery, or adaptive memory, was familiar to all manufacturers. However, none of those contacted were certain that the call for supplementary heating would be entirely suppressed.

Given this information, the issues arising from requirements for heat pumps in the NECH should be further studied.

NECH Energy Source Classification For Wood

Another issue arising from the NECH requirements regards the classification of wood with electricity, under the "Other" energy source classification.

In discussion with NRC staff, it was reported that the rationale for this classification was as follows:

- Electrical resistance supplementary heating is generally provided where wood is used as a principal source of energy; and
- The emissions from the combustion of wood were deemed to cause equivalent environmental damage to those produced in the generation of electricity.

It was pointed out that no analysis confirming this rationale was performed, rather this represented a consensus view among committee members.

Research indicates that U.S. Environmental Protection Agency (EPA) rated wood burning equipment generates very low levels of pollution compared with conventional and generally less efficient appliances. Further, new growth in Canadian forests yields approximately 1 cord/acre/year, and provided this level of harvesting is not exceeded, the closed carbon cycle associated with wood burning is sustainable.

Some interest groups in Ontario feel that air source and ground source heat pumps often require more than 10% of the total heat delivered, to come from supplementary electric heating, hence these should be treated in the same manner as wood heating. The means by which the 10% threshold for supplementary heating energy sources may be determined is not explicitly documented in the NECH, hence validation of this concern is difficult to perform.

Clearly, the rationale provided for these requirements remains controversial, and this indicates a need to look deeper into the intent of the requirements. Intent has not been consistently documented for many of the NECH requirements, hence the discussion which follows is explorative and speculative.

Assuming that the intent of the NECH is to promote renewable energy use in Canada, then the approach taken to wood should be applied to all energy sources. Under this scenario, future generations would inherit a stock of housing with thermally efficient envelopes requiring relatively little renewable energy for space heating, thus extending the capacity of renewable energy reserves in Canada. If, on the other hand, the intent is to deliver least cost housing to consumers based on a life cycle corresponding to the typical duration of tenure (e.g., 30 years), then the capital cost of wood along with a minimum conversion efficiency should have been applied in a manner similar to all of the other energy sources.

At present, due to a lack of intent, no clear means of determining the 10% threshold for supplementary heating, and no analysis of wood commensurate with the methodology applied to other energy sources, it is not possible to conclude whether or not the requirements are appropriate.

NECH Window And Glazing Requirements

The thermal performance requirements for glazing under the NECH would set the minimum standard for windows as double glazed with low emissivity coating, having a nominal ER of -13, and an actual ER of -12.3 (RSI 0.50/R-2.8). This is well above the OBC minimum requirements and represents a significant impact, not so much in terms of capital costs (see Table 3.15), but in terms of how long it will take the window industry to accommodate this increased demand for low emissivity glazing materials. This aspect of the NECH requirements for windows and glazing is dealt with in greater depth in Chapter 8.

Another controversial aspect of the NECH requirements regards the promotion of passive solar heating. Some interest groups have pointed out that a minimum solar aperture should have been incorporated into the requirements to promote the potential of high performance windows in reducing non-renewable energy demands. The limit imposed by the NECH of 20% (40% for selected south windows) of the floor surface area of the building was also viewed as inappropriate, again based on a lack of rationale. It is beyond the scope of this study to investigate passive solar potential and the optimal levels of fenestration in new housing for purposes of daylighting and energy efficiency. It does appear, however, that more rationale supporting current NECH requirements is needed, particularly in light of emerging window technologies.

Potential Impact Of Trade-Offs

Under the NECH requirements, trade-offs against prescriptive requirements may be permitted provided the above-ground envelope effective thermal resistance is not reduced to less than 80% of the prescriptive levels, and other opaque separators (basements) and windows to less than 60%.

A concern has been raised regarding the potential impact of trade-offs on thermal comfort and condensation control. It is beyond the scope of this study to perform detailed hygrothermal analyses of various assemblies, however, some general observations regarding plausible scenarios in Zones 1 and 2 have been considered.

In Zone 1, a 20% reduction in the effective thermal resistance of walls in electrically heated homes translates into an RSI 3.80 (R-21.6) nominal insulation level. This would permit the elimination of exterior insulating sheathing and hence the potential for interstitial condensation would increase significantly.

Assuming the adoption of NECH levels for gas heated homes, trade-offs in walls would permit a reduction in the nominal thermal resistance from RSI 3.0 (R-17) to RSI 2.4 (R13.6). This could translate into the use of 2 x 4 construction with a low conductivity exterior sheathing (structural). Some impact on thermal comfort during extremely cold periods, along with an increased potential for interstitial condensation may be expected under this scenario.

Basement and window performance under the NECH requirements would not be significantly impacted in Zone 1 since trade-off reductions would typically translate into the thermal resistance levels of current construction practice.

In Zone 2, trade-offs for electric and gas heated homes could see wall construction revert to 2 x 4 construction with varying levels of exterior insulating sheathing, and in the case of gas heated homes, 2 x 6 construction without exterior insulating sheathing would also be permitted. The former scenario may reduce thermal comfort levels during extremely cold weather, yet actually decrease interstitial condensation potential, depending on the type and thermal resistance of the exterior insulating sheathing used. The latter scenario would represent a regression from current practices in much of Northern Ontario where the thermal comfort benefits of exterior insulating sheathing have been recognized. Again, basement and window performance in Zone 2 would not be significantly impacted by trade-off reductions.

The brief analysis presented above assumes that ceiling insulation, basement insulation and window performance will typically be upgraded to gain trade-offs in exterior walls. In practice, building officials may decide to consider appliance efficiency trade-offs, despite present NECH restrictions against this approach, based on their interpretation of the intent of the requirements for energy efficiency. The importance of an explicit intent and rationale for energy efficiency requirements can be appreciated under such circumstances. The long term benefit of reducing the thermal resistance in assemblies which are difficult to upgrade and retrofit is also called into question.

7. Adoption Issues

This section of the report is intended to deal with aspects of adopting the NECH in Ontario which are not directly related to costs and benefits normally associated with consumers of housing.

Two consultative sessions were conducted to gain insight into adoption issues from a broad range of stakeholders The first, on April 7, 1995 involved building industry representatives and the second, held on April 20, 1995 involved building officials.

A hybrid focus group/buzz group approach was used to assess the industry views. Results of the economic aspects of the study to-date were presented to the entire group of participants at each session. The large group was subdivided into buzz groups ranging from two to six individuals. A number of discussion questions were presented to buzz groups to focus discussion on issues considered important. Groups were free to discuss any other issues felt to be relevant. Each group was asked to summarize their discussion, elect a spokesperson and report back to the larger group.

The objective of these sessions was to provide an overview of the study findings to-date, and to obtain feedback from the stakeholders with regards to their particular concerns. The adoption issues relating to the NECH are manifold, and these are more fully identified later in this section of the report. In broad terms, however, adoption issues may be categorized as follows:

- ***First Costs Implications*** - the difference in costs associated with the adoption of the NECH in Ontario;
- ***Industry Impacts*** - impacts on builders, suppliers and manufacturers;
- ***Code Enforcement*** - plans, permits, inspections and the technical documentation which will be required; and
- ***Administration, Supervision, Co-ordination*** - the implications for paperwork, site supervision and dealing with suppliers of equipment and materials.

Information packages were developed for each of the focus groups, including a series of issues to be considered and discussed. These were circulated in advance of the sessions to enable participants to appropriately prepare for the focus groups.

This section of the report will first present a summary of each of the focus group sessions followed by a synopsis from the sessions. An analysis of the results of the focus groups is presented in the next chapter.

Building Industry Focus Group

The building industry focus group consisted of a broad cross-section comprising builders, manufacturers, and a number of housing industry related organizations. A listing of the attendees is provided below.

Building Industry Focus Group, April 7, 1995	
NAME	***ORGANIZATION***
Norval Collins	CEF Consultants
Brett Barnes	Canada Mortgage and Housing Corporation
Henry Tse	Ontario Building Officials Association (OBOA)
Richard Lipman	Canadian Window and Door Manufacturers Association
Steven McKerlhen	Plastmo Ltd.
Mark Patamia	Ontario Concrete Block Association
Luc Fornoville	Canada Brick/Clay Brick Association of Canada (CBAC)
Cameron Ridsdale	Canadian Portland Cement Association
Catherine Lalonde	Canadian Wood Council
Michael Henville	Ontario Hydro
Dave Craddock	Ontario Association of Architects
Robert Marshall	Ontario New Home Warranty Program
Bernie Roth	Toronto Area Chief Building Officials Council (TACBOC) & Chief Building Official - City of Scarborough
Joyce Feinberg	Consumers Council of Canada
Ian Cook	Ontario Home Builders Association
Dave Henderson	Ontario Home Builders Association
Rob McInnes	Society of the Plastics Industry of Canada
Keith Wilson	Canadian Association of Man-Made Vitreous Fibre Manufacturers (CAMMVFM)
Mike Lutman	Heating, Refrigerating and Air Conditioning Institute of Canada
Gord Arnott	Heating, Refrigerating and Air Conditioning Institute of Canada
Bill Wilson	Ontario Realty Corporation

A listing of the issues which the group was asked to consider is provided on the following page. Responses were recorded in relation to these issues, and are summarized respectively.

Building Industry Issues

The following issues were identified throughout the course of the study and presented to the building industry focus group for their consideration.

1. What are the implications for your organization, members or constituents should Ontario reference the NECH within the OBC?
2. What level of interest is there for using trade-offs and performance assessments, particularly as a means of getting credit for innovation? What problems do you foresee (if any) in the adoption of a trade-off and performance compliance path?
3. Will the higher window standards of the NECH pose a problem for the industry?
4. Will the NECH pose any problems for the HRV industry?
5. How critical is the difference in costs associated with the NECH to business operations? In other words, what is the maximum threshold for construction cost increases on a per house basis?
6. Additional paperwork and documentation may be required with the adoption of the NECH. Will this impose an undue burden on the industry?
7. Do changes to Codes affect on-site productivity? Will this have an impact on construction costs?
8. Should Ontario proceed with the adoption of the NECH?
9. What should the next steps be?

A summary of the responses to these questions follows.

Building Industry Perspective

The following responses were obtained from the focus group in relation to the issues summarized on the preceding page.

Issue #1 - General Implications

- OHBA concurred with CHBA and felt it was not appropriate to reference the NECH in the NBC. Increased regulation would make it more difficult to do business than presently under the existing regulatory framework. The benefits associated with increased regulation provide negligible positive impacts.
- While national standards are laudable, more effort would be required to effect changes to the energy requirements of the Ontario Building Code in the future should the NECH be referenced. Necessary changes would be likely be constrained to some extent by the NECH review timetable.
- There is a need to simplify building codes for housing - the OBC is already too complex. The industry is still dealing with 1990 and 1993 OBC changes, and the industry's ability to accommodate further change must be considered. Rather than adopting the NECH, it was suggested to take appropriate parts of NECH and incorporate them into OBC.
- A consumer perspective was presented suggesting that as housing becomes more and more complex homeowners are left to deal with the complexity, often with equipment and systems being neglected or misused. Participants questioned who would train homeowners.
- Some concern was expressed as to the long term performance of mandated systems and equipment. It was suggested that long term performance and maintainability be key considerations of proposed Code changes.
- A need to consider the big picture was recommended when dealing with Code changes. As extra first costs are increased for housing due to Code changes, the reduction in builders' profits in tight markets translate into less tax revenues for the government, which must cope with the higher costs for regulation and enforcement associated with these Code changes. This negative spiral should be addressed at the outset of future Code change cycles.

Issue #2 - Trade-off and Performance Compliance Paths

- The industry will continue to predominantly use the prescriptive requirements of the Code. Of the few exceptions, trade-offs will likely be used more often than the performance alternative, hence some simplified means of dealing with trade-offs in the Code would be helpful.
- There was a concern expressed that the performance path should not allow increased mechanical system efficiencies to detrimentally undermine envelope system efficiencies. The potential for regressive practices should be minimized.
- The issue of airtightness, and airtightness testing was raised with regards to the NECH requirements, however, this was not seen as being problematic provided builders and code enforcement officials maintained current practices.

Issue # 3 - Window Standards

- In view of the NECH requirements for higher window standards in gas heated houses, the potential impacts were seen as being dependent on the timing and ramp-up of new Code requirements. First costs were viewed as not being significant in the long term as the entire industry moves toward higher standard products. The transition process was identified as being the most critical consideration.

Issue #4 - HRV Requirements

- HRVs are more common under NECH requirements and there was general consensus that more training would be needed in their proper installation and inspection, particularly given the experience with the latest amendments to the OBC.
- Manufacturing capacity was not viewed as being problematic.
- The focus group suggested that a $1200 premium, rather than the $600 premium used in the study, was more appropriate for HRVs, based on normal practices in Ontario. HRAI pointed out that the $600 premium represents a common and effective type of HRV installation using less expensive and efficient equipment.

Issue #5 - First Cost Implications

- In general, it was pointed out that consumers are willing to pay more for improved energy efficiency in housing provided they understand the benefits. Others felt that consumers were willing to pay more for upgraded kitchens rather than improved energy efficiency.
- A fuller exploration of the real costs of maintenance and servicing for mechanical equipment is needed to appreciate the impacts of NECH requirements.
- Whether or not banks actually consider principal, interest, taxes and energy (PITE) was questioned.
- Fuel differentiation was questioned in view of the uncertainty associated with long term fuel pricing.
- The hidden costs associated with Code changes (e.g., training, education, administration, etc.) should be considered along with other first costs.

Issue #6 - Documentation/Enforcement

- There would be some increase in documentation required, but it was not clear to the group exactly what the extent of this might be.
- It was recommended that the Code define who is competent to perform airtightness testing and trade-off/performance compliance, and the level of documentation required, otherwise non-uniform requirements would be imposed across Ontario municipalities.
- Municipal inspections would likely be impacted. These may need to increase or be of longer duration. More disputes may likely result.

Issue #7 - Productivity Impacts

- Productivity was seen to be impacted negatively by Code changes, but this occurs mostly at the sub-trade level and during the ramp-up period.

Issue #8 - Adoption in Ontario

- The general view was that only the appropriate parts of the NECH for housing be adopted in the OBC. The wholesale changes required to the existing Code structure and the ramifications for adapting to these changes were not viewed as worthwhile given the slight difference between the OBC and NECH.
- Some questioned whether the NECH went far enough.

Issue #9 - Next Steps

- National harmonization of Codes is an ideal which should be met in spirit if not to the letter. The OBC has to continue to respond to Ontario's requirements within this context.
- Clarify how the NECH requirements will apply to existing housing, and in particular, its relation to Part 11.
- Provide opportunities for further consultation prior to the next Code change cycle with respect to the NECH as it is finally proposed.
- Training and education initiatives should precede any adoption of the NECH.

Building Officials Focus Group

The building officials focus group consisted of representatives from both large and small municipalities. A listing of the attendees is provided below.

Building Officials Focus Group, April 20,1995	
NAME	***ORGANIZATION***
Tony Boyko	Town of Markham and TABIC
Chris Bird	M.A.C.I.C.
Madeline McBride	Natural Resources Canada - Energy Code Support Program
Michael Henville	Ontario Hydro
Cedric Smith	City of Scarborough (MSAC) and (OBOA)
Peter Sectakof	City of Toronto (MSAC)
Allan Jenkins	Ministry of Environment and Energy
Ralph Di Gaetano	Ministry of Housing
Douglas Head	OBOA - Small Municipality Township of Smith
Henry Tse	Town of Halton Hills (OBOA)
Ali Arlani	Ministry of Housing
Michael DeLint	Ministry of Housing
John Haysom	Canadian Codes Centre/NRC

Code Enforcement Issues

The following issues were identified throughout the course of the study and presented to the building officials focus group for their consideration.

1. What are the implications for your municipality should Ontario reference the NECH within the OBC? Do you foresee any enforcement problems for your municipality?

2. Additional paperwork and documentation may be required with the adoption of the NECH. Will this impose on undue burden on the enforcement industry?

3. Are there aspects of the NECH that will be difficult to enforce?

4. Trade-off and Performance Compliance Paths:
   a) What problems do you foresee (if any) in the adoption of a trade-off and performance compliance path?
   b) What level of documentation will your municipality likely require of the permit applicant that chooses the trade-off or performance path?
   c) What demonstration of competence (i.e. professional engineer, licensed architect, HRAI certification, etc..) would you recommend as necessary for a) trade-off compliance or b) performance compliance? Could plans and designs be certified by trained architects, engineers or designers as a means of streamlining approvals? Would liability insurance be required of these individuals? Is liability insurance currently required for other aspects of the Code (e.g. Part 4 design)?
   d) Could construction be certified by builders to streamline inspections?

5. Could special energy code inspectors/plans examiners be used to check for NECH compliance in your municipality? Could the private sector play a role in this aspect of OBC enforcement?

6. a) What is the nature of additional costs (if any) that may be imposed on the enforcement industry and on your municipality specifically if the NECH is adopted?
   b) Will the adoption of the NECH impact permit fees?

7. Will additional education and training be required for enforcement officials in your municipality? Will this present a financial burden to your municipality?

8. Are there enforcement issues that need to be considered that relate to the windows (low-E and low-E argon) that may be required by the NECH? Labelling requirements?

9. Should Ontario proceed with the adoption of the NECH?

10. What should the next steps be?

A summary of the responses to these questions follows.

Building Officials Perspective

The following responses were obtained from the building officials focus group in relation to the issues summarized on the preceding pages.

The perspectives are summarized according to the views of both large and small municipalities' building officials, and noted respectively where these differ significantly.

Issue #1 - Municipal Implications

- Increased levels and quality of documentation would generally be required under the NECH, particularly in the detailing of plans. Higher quality plans for housing were foreseen as becoming normal practice.
- The airtightness provisions of the NECH were viewed positively, but enforcement and airtightness testing may prove problematic. A concern was expressed regarding the qualifications of airtightness testers, and what would happen in the event a house failed to pass a mandated airtightness test.
- Inspection of items such as HVAC equipment characteristics and outdoor lighting were viewed as being problematic for many municipalities. It was suggested that electrical inspection services would continue to be offered by Ontario Hydro.

Issue #2 - Documentation

- Increased documentation would likely impose an increased burden on the industry and building departments under the NECH, however, this was viewed as being relatively minor compared to 1993 OBC mechanical ventilation changes.
- Additional time for inspection of materials and equipment was seen as translating into a higher workload for building departments, accompanied by a small increase in documentation.

Issue #3 - Enforcement Problems

- The only foreseeable enforcement problems related to lighting and electrical requirements and to the trade-off and performance compliance paths. In both cases, the building officials would have to deal with unfamiliar situations requiring specialized knowledge and training.

Issue #4 - Trade-off and Performance Paths

- Trade-off and performance compliance paths were not viewed as potentially causing significant problems, since the present OBC option for thermal design (OBC Section 9.38) is rarely used by industry. It could result in more paperwork and documentation.
- Under the performance path, some municipalities felt that the individual performing the assessment be either an engineer or architect, and possess liability insurance. This requirement lessened the need for building officials to become expert in the use and interpretation of compliance software.
- Enforcing trade-off compliance could be difficult depending on how difficult it is to check. Some standard trade-offs should be developed for use by building departments and industry.
- Some training would be required under these compliance paths for building officials in order to smoothen the transition.

Issue #5 - Private Sector Involvement

- There was a strong consensus that there was no role for the private sector in enforcing NECH requirements. The prime concerns centred about, liability implications, duplication of services, conflict of interest, lack of knowledge within the private sector, and no status for private sector involvement under the Building Code Act.

Issue #6 - Costs and Permit Fees

- The hard costs associated with NECH adoption were identified as training, the development of new forms and checklists, as well as the purchase of the NECH itself.
- Soft costs were identified as a possible reduction in the level of service presently provided, given that the same staff would have to handle more detailed plan examinations, inspection items and documentation.
- Permit fees were not foreseen to be impacted by adoption of the NECH. As stated earlier, adoption would likely impact service levels, or overtime costs.

Issue #7 - Training and Education

- Additional training and education for building officials was viewed as inevitable should the NECH requirements be adopted.
- While unable to quantify the magnitude of the financial burden, it was generally agreed that the municipality would incur a higher cost than at present.

Issue #8 - Window Standards Enforcement

- The standardized labelling of windows would be required to minimize the enforcement costs associated with higher window standards under the NECH.

Issue #9 - NECH Adoption in Ontario

- In general, building officials felt that Ontario should not reference NECH in Part 9. Instead, it was suggested that the OBC incorporate valuable improvements into Part 9, and address trade-off and performance in (OBC Section 9.38). This would enable Part 9 to remain as prescriptive as possible.
- The advantage of this approach is that officials and builders would only have to deal with one document (i.e., Part 9) without referencing another document. This is particularly important to the heating subtrades.
- Referencing the NECH in Part 9 would cause confusion for Part 9 buildings which are not dwellings as defined in the NECH. Part 9 would have to delineate when the NECH versus the NECB would have to be adopted.

Issue #10 - Next Steps

- The group felt that the most important next step was to become involved in the public commentary process with respect to the second draft of the NECH, and then to carefully consider which valuable parts of this version of the document to include in Part 9 of the OBC.
- Prior to implementing selected changes in the OBC, appropriate training and education should be developed to ensure a smooth transition for building officials and the housing industry.

Synopsis

Based on the feedback from the focus groups, a brief synopsis of the issues has been developed. These should be taken into consideration in addition to the many technical and economic aspects of NECH adoption presented earlier in this study.

- The benefits of adopting the NECH in Ontario are outweighed by the negative impacts associated with Code changes, (and the prescriptive structure of Part 9 may be compromised in the process).
- The potential for simplifying Part 9 of the OBC would be hampered by referencing an external document of significant complexity to the industry. Future changes to the OBC would be tied to an external process (its timing and structure).
- The most appropriate aspects of the NECH should be integrated within Part 9 of the OBC, and the trade-off and performance compliance paths should be addressed under a revised OBC Section 9.38.
- Further consultation should take place prior to making any firm decision regarding adoption of the NECH, in whole or in part.
- Training and education prior to the implementation of any Code changes are key to a successful transition to new requirements.

8. Assessment of Implications

This part of the report is intended to provide an assessment of the implications associated with adoption of the NECH. The potential implications have been categorized as follows:

- ***Economic Implications*** - the difference in costs associated with the adoption of the NECH in Ontario, including additional requirements for documentation, site supervision and dealing with suppliers of equipment and materials;
- ***Construction Practice Implications*** - implications for builders, suppliers and manufacturers arising from required changes in construction practices;
- ***Code Enforcement Implications*** - implications for plans, permits, inspections and the technical documentation which will be required; and
- ***Code Development and Housing Energy Policy Implications*** - the implications for Ontario's building code development process and the formulation of housing energy policy.

Before an assessment of the implication of adopting the NECH in Ontario may be performed, it is necessary to outline the various NECH adoption alternatives which are available. Having established these, the assessment of implications will deal with the implications corresponding to each of these scenarios.

NECH Adoption Alternatives

In reviewing the relationship between the National Energy Code for Houses and the current provisions for housing energy efficiency in the Ontario Building Code, essentially three alternatives are available for adoption of the NECH. These are summarized in Table 8.1, which provides a synopsis of the advantages and disadvantages associated with each of the alternatives.

Table 8.1
NECH Adoption Alternatives for Ontario

ALTERNATIVE	ADVANTAGES	DISADVANTAGES
Rejection of NECH	No changes for builders, manufacturers and the code enforcement community. Ontario's housing sector can maintain "business as usual" following the last series of major OBC revisions (1993).	Harmonization of provincial building codes with the NBC is not facilitated. Cost effective improvements to housing energy efficiency within the NECH are not adopted. Cost/benefit methodology for evaluating energy efficiency improvements is not institutionalized.
Selective Adoption of NECH	The most appropriate aspects of the NECH for Ontario may be prescriptively incorporated into the OBC, and the trade-off and performance compliance paths of the NECH are made available under Section 9.38 *Thermal Design*.	The process of determining appropriate aspects for inclusion within the OBC will require a considerable allocation of resources. Some training and education resources will need to be directed towards transferring revised OBC prescriptive requirements to industry and enforcement community. Technology transfer and learning curves associated with a revised OBC Section 9.38 *Thermal Design* will consume significant resources during the transition.
Complete Adoption of NECH	The harmonization of inter-provincial building codes is better fostered, and the costs associated with future development of energy efficiency requirements within the OBC are minimized. Government resources may be directed toward other aspects of code development and energy efficiency housing policy.	Some training and education resources will need to be directed towards transferring revised OBC prescriptive requirements to industry and enforcement community. Technology transfer and learning curves associated with a revised OBC Section 9.38 *Thermal Design* will consume significant resources during the transition. In this process, Ontario would abrogate much of its control over the code development process in relation to energy efficiency in housing.

Based on the three adoption alternatives outlined in Table 8.1, an assessment of the associated implications follows.

Economic Implications

First Cost Implications

The first costs implications of the three adoption alternatives are presented below. The large two-storey benchmark house provides the basis for comparison under the complete NECH adoption scenario. This generally represents the largest difference in first costs associated with adoption of NECH requirements in Ontario.

1. There are no first costs implications associated with the NECH rejection scenario.
2. Depending on the aspects of the NECH which deviate from current OBC requirements, the selective adoption scenario will involve a range of first costs implications. At the lower end, first costs would be minimal, and at the higher end, additional first costs would approach those under the complete adoption scenario.
3. If completely adopted, first costs implications would vary, in some cases with the NECH requirements costing less in some cases, while in other cases, costing more. In Zone 1(A), electric resistance heated and wood heated dwellings would cost approximately $700 more under the NECH - $1,300 more in Zone 2(B). Air source and ground source heat pump conditioned dwellings in Zone 1(A) would cost approximately $2,000 and $3,500 less, respectively, under the NECH - $300 and $2,000 less respectively in Zone 2(B). Oil and propane heated dwellings would cost approximately $1,800 more than present OBC requirements in Zone 1(A) - $2,000 more in Zone 2(B). Natural gas heated homes would cost approximately $300 more under the NECH in both zones. These differences in first costs are based on the costing data utilized for development of the NECH.
4. Based on views expressed at the focus group meetings, it is not expected that first costs associated with the enforcement requirements pertaining to the NECH will be impacted through higher building permit fees.

The recognition by financial institutions of PITE (principal, interest, taxes and energy) formula as part of mortgage eligibility criteria would improve the ability of homeowners to access the increased funds required for energy efficiency improvements, particularly where total monthly carrying costs are lower than would otherwise be. Unfortunately, at this point financial institutions are not equipped to make judgements on the level of energy savings available, nor is a mechanism in place within the low-rise residential sector that could provide a guarantee for banks and trust companies (unlike the commercial or industrial sector that are served by ESCOs, energy service companies). At competitive mortgage rates it appears most financial institutions are unwilling to assume the risk associated with making their own determination of energy savings.

Operating Cost Implications

An analysis of the operating cost implications of moving to the NECH requirements for houses in Ontario reveals that:

1. yearly energy savings are largest for houses that are heated with oil or propane with a range from $300 (propane, Zone 2, large two storey) to $120 (oil, Zone 1, interior row);
2. yearly energy savings for gas-heated houses would range from less than $5 to about $75. Savings for Zone 1 houses are negligible. Savings for Zone 2 houses are larger and result primarily from the NECH requirement for heat recovery ventilation in these houses;
3. energy savings for electrically-heated houses range from about $10 to $90 per year depending on the type of house and its location. This translates into energy savings of less than 5% in most Zone 1 houses and less than 10% in most Zone 2 houses;
4. for the vast majority of houses built in Ontario small energy savings would be realized by adopting the National Energy Code for Housing; and
5. adopting the National Energy Code realizes energy savings in houses that currently are poorly served by the Ontario Building Code's provisions; that is, in oil or propane-heated houses.

Life Cycle Cost Implications

The analysis of the costs and benefits of adopting the NECH as measured by life cycle costs reveals that:

1. significant life cycle cost savings would be realized for houses that are heated with oil or propane;
2. houses equipped with air source or ground source heat pumps in most cases would benefit from adoption of the NECH; and

3. for the majority of houses in Ontario adopting the NECH provides insignificant life cycle cost benefits.

It should clearly be noted that the trade-off path will normally result in sub-optimal alternatives; that is, alternatives that are not cost-effective. It would be expected that trade-off choices will, in many cases, be driven by first cost considerations. This approach deviates from a methodology intended to minimize life-cycle costs. As such, the approach appears inconsistent with the prescriptive and performance approaches of the other parts of the NECH.

Economic Efficiency of Options for Gas-Heated Houses

Both the OBC and NECH requirements were developed from a life cycle cost optimization methodology. The requirements for each vary in minor aspects due to some changes in costs that have resulted since 1991 when the OBC analysis was carried out. As well, the NECH considered alternatives that were not among those analysed when the OBC requirements were fashioned.

A limited validation of the economic efficiency of the OBC and NECH requirements was carried out for gas-heated houses in Zone 1 and Zone 2. The validation involved examining an additional set of envelope alternatives that exceeded those of the NECH. The alternatives represented the next logical increment in ceiling, wall and foundation insulation and are presented in Table 8.1 and 8.2 below. Windows were also examined.

Table 8.1
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Natural Gas Heated Dwellings

ONTARIO - Less than 5000 DD			
COMPONENT	OBC ZONE 1	NECH ZONE A	NECHplus ZONE 1
Ceiling	5.4(R-31)/*5.8(R-33.1)*†	5.6(R-32)/*5.8(R-33.1)*	7.0(R-40)/*7.2(R-40.9)*
Walls	3.25(R-19)/*3.1(R-17.4)*	3.0(R-17)/*3.0(R-16.9)*	3.25(R-19)/*3.1(R-17.4)*
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	2.1(R-12)/*1.9(R-10.8)*	3.25(R-19)/*3.4(R-19.2)*
Windows*	*-25**/0.39(R-2.2)*	-13**/*0.50(R-2.8)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

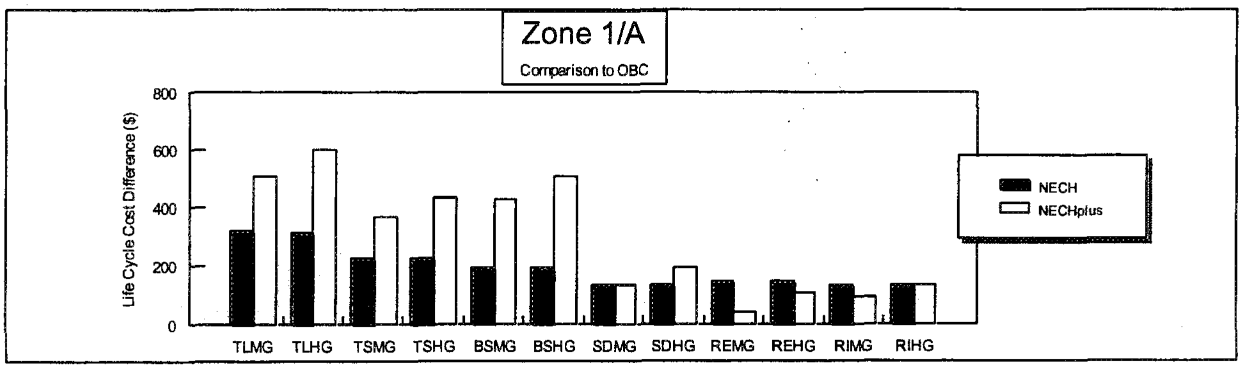
Table 8.2
Nominal and *Effective* Thermal Resistance Values Used In Energy Simulations of Natural Gas Heated Dwellings

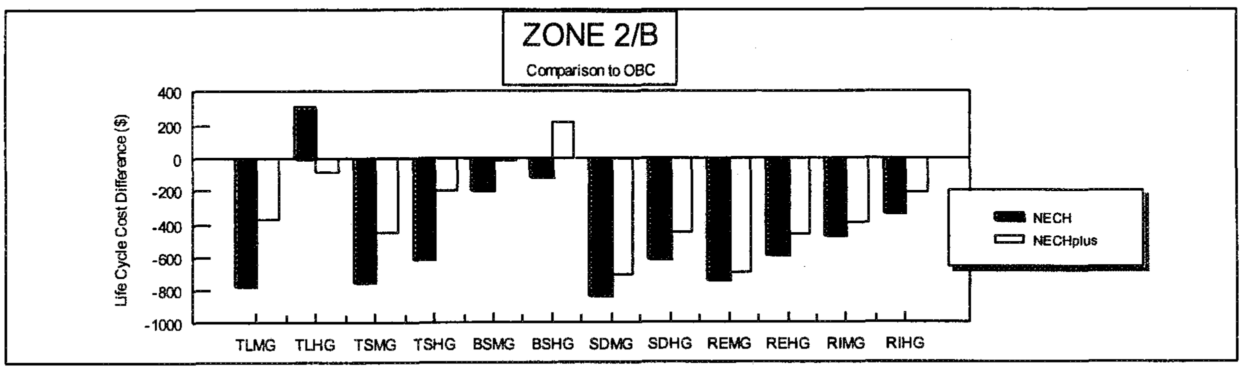
ONTARIO - 5000 DD and Greater			
COMPONENT	OBC ZONE 2	NECH ZONE B	NECHplus ZONE 2
Ceiling	6.7(R-38)/*6.9(R-39.4)*	7.0(R-40)/*7.2(R-40.9)*	8.8(R-50)/*9.0(R-51.1)*
Walls	3.87(R-22)/*4.0(R-22.5)*†	3.4(R-19.5)/*3.4(R-19.5)*	3.87(R-22)/*4.0(R-22.5)*†
Foundation Walls	2.11(R-12)/*1.9(R-10.8)*	2.1(R-12)/*1.9(R-10.8)*	3.25(R-19)/*3.4(R-19.2)*
Windows*	*-25**/0.39(R-2.2)*	-13**/*0.50(R-2.8)*	-13**/*0.50(R-2.8)*

*ER rating converted to effective R-value.
** Nominal ER -25 translates into DG, ER -23.2, SHGC 0.46.
*** Nominal ER -13 translates into DG low-e, ER -12.3, SHGC 0.45.
† Effective value reflects common practice in Ontario.

This set of alternatives, collectively known as the NECHplus buildings, were costed using the NECH capital cost data and simulated using HOT-2000 version 6.02 consistent with the other aspects of this study. A summary of the life cycle costs associates with the analysis is found in the Appendix to this chapter. Figures 8.1 and 8.2 summarize these results. The analysis reveals that:

1. for Zone 1 houses, in every case examined, the OBC alternative results in lower life cycle costs than any other alternative examined including the NECH;
2. for Zone 2 houses, in virtually all cases examined, the NECH alternative results in lower life cycle costs than any other alternative; and
3. the NECHplus alternative is not cost effective in virtually all cases examined.





Environmental Implications

Adoption of the NECH would have selected environmental benefits accruing from a small segment of all new home starts. Across the entire province the environmental benefits from adopting the NECH would be expected to be small.

Construction Practice Implications

There are several impacts to construction practice associated with the adoption of NECH requirements in Ontario. These relate primarily to continuity and effective thermal resistance of the building envelope, airtightness and mechanical ventilation. The implications associated with the complete NECH adoption scenario are presented below. They are arranged to facilitate an understanding of the implications associated with any selective adoption scenario.

1. NECH requirements for higher performance windows do not directly impact construction practices in terms of installation, however, greater attention will have to be paid to ensuring that windows meet specified performance levels. The specification and verification of appropriate window technology may be expected to involve costs associated with the learning curve in moving from the current to the NECH required practices. Window manufacturers and glass suppliers expect a smooth transition provided ample time is given for the conversion.
2. Requirements under the NECH for effective thermal resistance of building envelope components and continuity of the insulation represent a significant deviation from current OBC requirements. Builders will have to pay greater attention to the detailing of components, and may no longer refer to the installed thermal resistance value of insulation. In areas such as masonry fireplaces, construction detailing will have to ensure a continuous thermal barrier meeting the minimum effective thermal resistance value. First costs associated with these requirements were not considered in the NECH costing, and were not addressed in this study.
3. A performance level for airtightness allows building officials to request an airtightness test under the NECH. Use of new envelope systems or envelope systems that do not strictly conform to the prescriptive requirements of the NECH referenced document are circumstances under which it is reasonably foreseeable that building officials

may request confirmation of the NECH specified minimum level of airtightness with an air test. Issues of air tester qualifications that would be acceptable to the enforcement community remain unresolved.

4. Mechanical ventilation with heat recovery in Zone 1(A) oil and propane heated homes, as well as all homes in Zone 2(B), represents a change with respect to present OBC requirements. This will initially require proper co-ordination on the part of affected builders with their mechanical sub-trades. Continued and in some cases expanded mechanical sub-trades training would be necessary; particularly, in light of the ventilation system installation difficulties as the 1993 OBC amendments have been implemented.

5. The Canadian Manufactured Housing Association (CMHA) has indicated that the NECH *"could have a devasting effect"* on the log home industry. The effective thermal resistance of log structures does not, in most cases, meet the required targets as proposed in the NECH. This issue is being actively considered and may soon be resolved. Any contemplated adoption of the NECH by provincial authorities should be preceeded by further discussion with the CMHA that all log home industry issues have been addressed.

Code Enforcement Implications

During the focus group meetings, a number of issues regarding code enforcement of the NECH requirements were raised. The discussion which follows presents these as well as additional implications not raised by the participants.

1. Under either the selective or complete NECH adoption scenarios, the building industry will continue to almost exclusively elect the prescriptive compliance path. Tradeoff and performance compliance paths will account for a significantly disproportionate fraction of dwellings in comparison to the cost of developing and implementing simple, effective means of applying and enforcing these compliance alternatives.
2. While the NECH limits some aspects of a dwelling's thermal efficiency which cannot be traded-off, the nature of Code enforcement in Ontario permits building officials on a limited basis to consider and interpret equivalency. It is likely that a significant number of requests for interpretations will be made under the tradeoff path. Local interpretations may undermine envelope thermal efficiencies and introduce regressive practices under this compliance alternative.
3. The move toward a performance measure of airtightness, as opposed to the purely descriptive requirement presently found under the OBC, may open an entire series of issues. Homebuyers may elect to have an independent airtightness test performed during their pre-delivery inspection, potentially leading to legal problems for building officials, and possibly the ONHWP, in the event the dwelling is deficient. Airtightness may be allowed in some municipalities to be traded-off against insulation levels. The code enforcement focus group recommended that the Code define who is competent to perform airtightness testing and tradeoff/performance compliance, and the level of documentation required, otherwise non-uniform requirements may be imposed across Ontario municipalities. The CGSB Standard 149.10 "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method" called by the NECH identifies certification requirements. These need to be reproduced perhaps within the appendix of the NECH. Potential conflicts of interest (e.g., an insulation and airtightness contractor providing airtightness testing) must also be resolved prior to implementation of NECH airtightness requirements.

4. Documentation in building departments is expected to increase under the NECH, but not to a significant degree. Higher quality plans for housing are foreseen as becoming a normal requirement to ensure NECH compliance, and some delays in the issuing of permits may initially arise while builders make the transition to better quality plans and specifications. This shift in practice will require some building departments to allocate greater resources toward "over the counter" builder education.
5. Site inspections are expected to demand additional time for documentation of materials, assemblies and equipment. This will vary depending on whether the selective or complete NECH adoption alternative is adopted. Window requirements in the NECH represent the most significant requirements impacting enforcement practices, and will likely require a standardized labelling of windows to ensure broad-based compliance. NECH requirements for outdoor lighting and heat pump performance characteristics represent largely unfamiliar technology to residential building inspectors, requiring specialized training and knowledge. Manufacturer documentation and/or labelling would also be required as a convenient reference for building officials, otherwise broad-based compliance may be compromised.
6. Unless the NECH requires individuals permitted to perform a performance compliance assessment to be either an engineer or an architect, many building departments will have to become expert in the use and interpretation of compliance software for liability reasons. Most building departments will only be capable of dealing competently with the tradeoff compliance path in the NECH, and some qualifications to perform aspects of plan examinations and inspections associated with this path may need to be established. These will not be onerous provided standard tradeoffs are developed to simplify this path for building officials and builders, alike. It is expected that under any NECH adoption scenario, building official training would be required during the transition period, particularly in relation to the compliance path alternatives.
7. The hard costs associated with NECH adoption were identified as training, new forms and checklists, and purchase of the NECH itself. Soft costs were identified as a reduction in the level of service presently provided, given that the same staff complement would have to handle more detailed plan examinations, inspection items and documentation. Maintaining present service levels would entail higher overtime costs to municipalities.

Building Code And Housing Energy Policy Implications

The structure, methodology and assumptions inherent in the NECH potentially represent significant implications for Ontario's building code and housing energy policy development processes.

1. Ontario's progressive posture in the building code and housing energy policy development processes has historically involved pioneering novel methodologies of decision making which have typically considered much later at the national level. Complete adoption of the NECH would largely restrict Ontario's autonomy in these areas, and resources normally directed at these development processes may have to be redirected to stimulate the national process in order to provide timely solutions to Ontario's emerging issues. Ontario authorities having jurisdiction will have less control over any process coordinated at the national level.
2. It should be recognized that limiting the analysis to life cycle costs alone presents a biased view. Unfortunately, because few economic measures are as sharp as the life cycle cost analysis they are often overlooked. Nonetheless, cost implications to builders, municipalities and society - cost outside the traditional life cycle cost measures - are ultimately borne by the consumer in one form or another and need to be formally considered within any cost benefit methodology. These costs may manifest themselves as higher warranty program registration fees, higher lot levies and higher tipping fees for instance. The societal impacts are significant and can be as important if not more important than the life cycle measures. Some attempt was made to capture these costs within this study particularly as they relate to environmental externalities.
3. Related to 2 above, a life cycle costing methodology used for the selection of building systems that is limited to energy efficiency considerations alone is biased. Durability, adaptability, operation, maintenance and replacement considerations impact system selection decisions and therefore need to be embodied within the life cycle costing methodology. This implies a need fro explicit performance criteria for buildings that can be objectively evaluated.
4. Adoption of the NECH may pose a barrier to future initiatives involving simplification of the building code for housing. This is in part due to the reduction in autonomy associated with Ontario's role as one of many national

interests in the NECH. As well, NECH requirements above and beyond current OBC requirements will render what some interest groups feel is already an over-complicated regulatory document, even more cumbersome. A number of interest groups have expressed concern at the ever-increasing number of referenced documents within the OBC. Continued support of each referenced document by the issuing organization has recently emerged as one of the fundamental assumptions that may no longer be valid. In these cases, authorities having jurisdiction may be forced to re-examine the extent of referenced documents. References to documents within referenced documents has also emerged as an issue deserving of attention. Conforming to secondary and tertiary references it would appear also becomes the responsibility of the permit applicant/builder. These requirements may then also need to be enforced by Ontario's building officials. Examination of this issue as it relates to the NECH reference to the Ontario Energy Act is needed.

5. Benefits associated with adoption of the NECH in Ontario are marginal, however, the costs to government associated with its implementation are likely to divert diminishing resources away from many pressing initiatives. Failure to appropriately address these timely issues may have an adverse effect on the credibility of Ontario's building code and housing energy policy development processes.
6. Unless comprehensive planning for the future of building code and housing energy policy in Ontario is undertaken and completed prior to deciding any NECH adoption alternative, the full benefit from Ontario's participation in the NECH process to date may not be realized.

Synopsis Of Implications

This synopsis of implications for adopting the NECH in Ontario is based on the three adoptions scenarios presented earlier in Table 8.1. In all cases, little or no energy, economic and environmental benefits will accrue.

- If the NECH is not adopted in Ontario:
  - some opportunity to capture cost effective energy efficiency within the OBC will be lost;
  - a return on the investment of valuable time and effort by many Ontario interests in the NECH development process will not be realized;
  - the goal of national harmonization of provincial building codes will not be furthered; and
  - industry interest in a simpler Building Code that focuses on health and safety will not be furthered.

- If the NECH is adopted selectively:
  - positive aspects of the NECH can be appropriately incorporated into the OBC to cost effectively improve energy efficiency;
  - the current structure of the OBC will be retained minimizing disruption to the homebuilding industry;
  - Ontario will remain free to continue its development of the building code and housing energy policy without being hamstrung by interests outside of Ontario; and
  - the intent of the NECH will have been effectively met in spirit, if not to the letter.

- If the NECH is completely adopted:
  - No significant improvement in housing energy efficiency would be realized, however, the transition would place a considerable demand on diminishing resources available for future building code and housing energy policy initiatives;
  - The potential for simplifying Part 9 of the OBC would be hampered by referencing an external document of significant complexity to the homebuilding industry; and

- New decision making methodologies for appropriate building code and housing energy policy development in Ontario would require a national consensus prior to their implementation within the NECH and thus the OBC.

This assessment of implications is based on the findings of the study to date, and also incorporates the views of numerous interest groups who participated in focus groups. New data and cost effectiveness assessment methodologies may lead to changes in some aspects of this assessment, however, the growing resistance to change voiced by Ontario's homebuilding industry, building officials, builders, manufacturers and consumers alike, should not be expected to suddenly reverse in this eventuality.

9. CONCLUSIONS AND RECOMMENDATIONS

This part of the report presents a series of conclusions and recommendations regarding implications of adopting the National Energy Code for Houses in Ontario.

The conclusions and recommendations are first presented integrally within the context of the preceding parts of this report, followed by a summary of conclusions and recommendations.

Topical Conclusions And Recommendations

Topical conclusions and recommendations have been organized into sections as follows:

- ***NECH Structure and Methodology;***
- ***Economic Implications;***
- ***Environmental Impacts;***
- ***Changes in Construction Practice;***
- ***Code Enforcement; and***
- ***Code Development and Energy Efficiency Policy***.

Each of these sections provide specific conclusions and recommendations based on the study conducted to date.

NECH Structure and Methodology

1. Given the differences in structure between the NECH and the current provisions for energy efficiency in the OBC, it may be concluded that complete adoption of the NECH in lieu of OBC provisions would represent a major transition for the homebuilding industry in Ontario.
2. Based on the similarity in the methodology underlying the proposed NECH and existing OBC requirements, it may be concluded that selectively adopting NECH prescriptive, trade-off and performance compliance paths will not significantly impact the energy efficiency of new housing in Ontario.

3. Existing OBC and proposed NECH prescriptive requirements are derived from assumptions regarding the performance of building envelope and mechanical systems. Many of these have not been validated in the field, and for the most part involve HVAC systems. Actual occupant operation patterns (e.g., mechanical ventilation rates), seasonal efficiencies, maintenance, repair and replacement costs are not readily available, hence ideal performance is often modelled in house operating energy simulations. This limitation should be addressed in future analyses by researching in greater depth the lifecycle costs of space heating/cooling, domestic water heating and mechanical ventilation systems. Industry cooperation is foreseen as a critical aspect of bringing about this improvement.
4. The methodology for cost effectiveness should, as much as is practically possible, be applied consistently throughout the energy code development process. Requirements pertaining to items such as wood heating, setback thermostats, exterior lighting controls, etc. should be supported with equivalently rigorous analyses similar to those performed for thermal insulation. It is recommended that unless requirements are empirically supportable, they should not be advanced in future drafts, since interest groups outside of the code development process are left with the often costly task of assessing potential impacts.
5. Deficiencies, such as basement leakage, window condensation, etc., and the associated costs for their correction have not been incorporated into the NECH cost effectiveness analyses. It is recommended that the latest data from the ONHWP be incorporated into future analyses to enable distinctions between alternatives based on more than energy cost effectiveness alone.
6. Externalities, to the extent possible should be carefully considered as part of a formal methodology. All costs and benefits, quantifiable and otherwise, currently outside the scope of traditional life cycle cost analyses should be considered as part of future code development efforts.
7. Newly developed codes should attempt to more explicitly document the intent and rationale underlying their requirements. Public review, code enforcement body interpretation, and future development of codes has been found to significantly improve when the explicit documentation of intent and rationale is readily available in a concise format.

Specifically related to the technical requirements of the NECH it is recommended that:

1. A rigorous, empirical analysis of the impacts of exterior lighting controls is needed to confirm the cost effectiveness of these devices.

2. The actual, versus the theoretical, performance of setback thermostats along with an assessment of impacts to the house-as-a-system (i.e., comfort and window condensation), and to energy distribution systems is required to confirm the cost effectiveness and desirability of these devices.

3. Requirements for heat pumps should be validated by field testing to ensure that the intended level of performance is provided by installed technologies. The fraction of electric resistance heating delivered by typical systems should be established through field monitoring.

4. The methodology for the calculation of the 10% threshold which defines the principal heating energy source should be established, and then applied consistently to all energy sources and conversion technologies*. As well, the rationale justifying the appropriateness of the 10% threshold should be developed and circulated for review and comment prior to its adoption. (* Lighting and internal gains due to electric appliance operation, often account for more than 10% of a dwelling's space heating, hence NECH criteria could be interpreted so as to define all dwellings as being electrically heated.)

5. The criteria for maximum permissible glazing area are lacking clearly documented, quantitative substantiation. The NECH does not demonstrate the cost effectiveness of this requirement with the same rigour accorded to opaque separators. It is recommended that the 20% threshold be assessed in terms of its impact on some minimum required passive solar heating fraction of the dwelling.

Economic Implications

1. In general, due to the predominant utilization of natural gas for space heating in new housing, the life cycle costs associated with adoption of parts or all of the NECH are not significant.
2. Life cycle cost benefits are confined primarily to oil and propane heated houses.
3. First costs to municipalities will not be as significant as the recent series of 1993 revisions to the 1990 OBC, however, it may be concluded that a reduction in service levels rather than an increase in building permit fees will be experienced during the transition to NECH requirements.

Environmental Impacts

1. The most significant improvements in the energy efficiency of Ontario's new housing were gained through changes introduced in the 1990 OBC, and the recent 1993 revisions. As a result, the environmental benefits associated with reduced emissions provided under the NECH are not significant.
2. It has been concluded that since annual new housing starts in Ontario normally account for approximately 1% of the total housing stock in the province, further improvements in new housing energy efficiency will not significantly reduce environmental impacts. Nonetheless, cost effective energy efficiency is available in selected new housing types by adopting the NECH requirements.
3. Related to item 2 above, it is recommended that building code and housing energy policy initiatives aimed at improvements to the energy efficiency of existing housing stock be given higher priority than requirements for new housing.

Changes in Construction Practice

1. Continuity and effective thermal resistance of the building envelope represent positive improvements to the energy efficiency of dwellings, and it is recommended that these requirements be adopted within the OBC. Insulation manufacturers should be encouraged to develop 'builder friendly' literature indicating the effective thermal resistance of various assemblies and details. Guidelines for insulating masonry fireplaces should also be developed, otherwise zero clearance fireplace technology will remain the only viable option for builders.
2. Window performance is steadily improving and the incremental costs associated with higher performance windows are becoming marginal. NECH requirements for windows will not be onerous in the medium term (1997/98) when the next round of OBC revisions is expected to take place. The most critical issue related to broad-based compliance is an effective labelling program to minimize confusion when windows are being specified and later inspected. It is recommended that window manufacturers be encouraged now to develop a simple, effective labelling program which can be implemented in the medium term.
3. NECH requirements for heat pump equipment performance translate into higher priced and more sophisticated technology, however, it is cost effective providing it performs as simulated. It is presently difficult to confirm that these requirements have been met during a site inspection, since there are no requirements in the CSA standards to indicate these features on the equipment label. Assuming that lower efficiency technology is acceptable from an energy policy perspective for existing housing stock in Ontario, then there is no need to consider changes to the minimum CSA requirements. Instead, it is recommended that a simple, clear nomenclature for these advanced features be developed and required to be stated on equipment labels to facilitate inspection. It is expected that equipment not currently covered in NECH Table 5.2.11a (specifically burner-assisted, bi-valent heat pumps) would continue to be permitted. Clarification of this item may be necessary perhaps through an appendix note.

Code Enforcement

1. Under any NECH adoption scenario, it may be concluded that training for building officials will be needed, well in advance of implementation.
2. Ontario should clearly determine who is qualified to perform trade-off and performance compliance assessments, as well as who is qualified to perform airtightness testing and how potential conflicts of interest should be addressed.
3. It is recommended that responsibility for the development of forms, checklists, standard trade-offs, etc. not be left to each municipality. A model documentation package should be developed provincially and provided to municipalities as a guideline which may be adopted or appropriately modified.

Code Development and Energy Efficiency Policy

1. It is recommended that Ontario retain its autonomy with respect to building code and housing energy policy, at least in the short to medium term. This will enable appropriate strategies to be formulated with respect to pressing code issues (e.g., simplification/rationalization), and energy policy, in view of other jurisdictions experience with the NECH.
2. Many of the limitations in the models, assumptions and methodologies for cost effectiveness of energy efficiency improvements to housing have been recognized in Ontario for nearly a decade, yet no concrete steps have been taken to address these in a meaningful way. It is recommended that an appropriate decision making methodology be developed jointly by government and industry, which is maintained, updated and most importantly, accessible to all parties. The NECH offers a framework for institutionalizing this process, but lacks effective mechanisms for validating and updating the cost data, models and methodologies. Ontario should consider a more sustainable and effective process.
3. The strong focus of code and energy policy development on new housing overlooks the more significant opportunity for improvement of the existing housing stock. The development of appropriate code requirements and energy efficiency standards to govern renovation is needed now with the shift from a new construction to a renovation

dominated homebuilding industry. It is recommended that new housing energy efficiency deserves little additional attention in the short to medium term.

Summary Conclusions And Recommendations

The following conclusions and recommendations are intended to summarize the overall findings of the study, and to indicate the major steps which must be considered in the short to medium term with respect to the NECH.

1. Practically speaking, the NECH is equivalent to the present OBC requirements in terms of energy efficiency and cost effectiveness. A full reference to the NECH may demand the allocation of dwindling resources in exchange for marginal benefits. It is recommended that Ontario selectively adopt appropriate prescriptive aspects of the NECH within Part 9, and reference it under 9.38 Thermal Design as an alternative means of compliance. Table 9.1 provides recommendations on specific adoption items.

2. By many accounts the NECH development process was a good first attempt, particularly for those stakeholders directly involved. Nonetheless, improvements should be considered as a means of better serving the greater community. An integrated and comprehensive means of institutionalizing the decision making process for introducing energy efficiency improvements to housing in Ontario, both new and existing, is strongly recommended. It should first rigorously address the methodological and data limitations identified in the current process. Prior to each Code cycle, the latest methodology and data should then be accessible for review by all stakeholders and subject to their consensus approval. The results for analyses of alternatives based on this consensus methodology and data should then be circulated for review and comment when soliciting proposals for changes to the Code. Proposals for changes should require a clearly stated intent and rationale for committee consideration. A synopsis of the reasoning behind the adopted and/or rejected changes should be available to all stakeholders for future reference. By maintaining continuity within and between Code cycles, a more effective and streamlined process which better serves the interests of all stakeholders is possible.

3. The introduction of a performance concept in the form of a life cycle costing methodology to energy efficiency represents a positive first step towards all aspects of building performance. The introduction of a more holistic approach to evaluating building performance with explicit objective criteria is now recognized as an essential element of innovation. System interactions could then be more appropriately evaluated and unbiased optima prescribed.

4. The development of performance-based codes which do not restrict approaches to building, but which simply provide performance criteria with testing protocols, while well intended, raises many concerns. Any effective performance-based code must be explicit in identifying what is deemed to comply, how compliance is measured and who is entitled to measure compliance. These key considerations at times have not been explicitly provided within the NECH provisions. The OBC should clarify these issues where performance-based requirements are adopted.

Table 9.1
Specific Recommendations For Adoption Of Selected Aspects Of The NECH

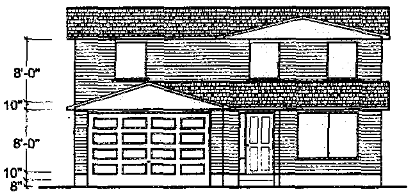
1.	The NECH prescriptive requirements as identified in NECH Tables 2.2.3A are similar to those of the OBC and contain enhancements that could benefit Ontario housing consumers. These should be adopted. In particular, the OBC should consider a finer differentiation of fuel types within Table 9.25.2.A. Two additional columns are recommended. These should be titled: Zone 1- Oil/Propane Heating and Zone 2- Oil/Propane Heating. Under this scenario only electric, oil and propane heated buildings would be subject to higher envelope insulation levels.
2.	The OBC provides specific requirements for the thermal resistance windows in non-electrically heated houses and references A440.2 for the windows in electrically heated houses. For non-electrically heated houses the OBC is not specific as to how the window thermal resistance should be derived (i.e. centre of glass, overall thermal resistance, inclusive of frame, etc...). A consistent approach for all windows is recommended.
3.	The NECH addresses in specific terms the interaction of service penetrations and insulation, particularly where the service penetrations might adversely affect insulative properties. The OBC is less specific. The NECH approach is recommended.
4.	The OBC is less specific about insulation continuity with only Article 9.25.4.1 addressing this issue in any way. The OBC should adopt the NECH's comprehensive approach. An exception for masonry built fireplaces that would minimize the disruption to the homebuilding industry needs to be balanced against not providing an exception in light of the serious impact of this thermal bridge on the total wall heat loss.
5.	The NECH has a useful definition of roof assembly not contained in the Ontario Code. Roofs are defined as the envelope elements less than 60 degrees from the horizontal. The OBC should include this definition.
6.	The insulation requirements at the roof eave differ from the current version of the OBC. The roof eave insulation must not be less than that required at the wall of the house within the NECH. This requirement would likely require houses to be built with roof structures that can accommodate the insulation. This was not considered as part of the cost analysis of this study. This item should be reviewed carefully prior to adoption, particularly its relationship to the requirements for eave protection (as poorly insulated top plates are often seen as contributing to ice damming problems).
7.	The NECH requires envelope insulation levels in houses heated with radiant heating be increased by 20% in the specific affected component. The OBC should adopt the NECH approach.
8.	The NECH insulation provisions for foundation walls apply only to walls less than 1.2 m (4 feet) above grade. Foundation walls greater that 1.2 m (4 feet) above grade are subject to the requirements for above grade walls. Where deep foundations are present insulation is not required 8 feet below grade. These distinctions are not made within the OBC. The OBC should include this provision.
9.	The NECH windows provisions appear well intended; however, they are overly complex and may be difficult to apply. Clarifying tables are needed to simplify the application. The OBC should carefully review this item prior to adoption.
10.	The airtightness requirements for windows and sliding glass doors of the NECH differ from those of the OBC. Adoption of the NECH requirements is recommended.
11.	Exterior door assemblies are expected to be designed to limit air leakage. Exterior door assemblies must leak less than 2.54 $L/s/m^2$ of door area based on the ASTM Standard E 283 *Standard Test Method for Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors*. It is unclear to what extent product complies with the requirements or whether the requirements are meaningful given the variability of installation practises. The alternative to the above test is that all doors be weatherstripped and equipped with a storm door or with an unheated vestibule. This appears to be an onerous requirement. This provision of the NECH is not recommended.
12.	Data from Consumers Gas suggests that 0.6 m (2') of hot water heater pipe insulation may be more appropriate than 2m (6'7"). Data also suggests that heat traps or pipe insulation but not both are called for. In general, it would appear that net savings are in the order of less than $1.00 per year. The magnitude of the yearly savings suggests that additional validation efforts are not warranted. Adoption of the NECH provisions is, therefore, recommended.

Appendix I

HOUSE IDENTIFICATION CODES

Location	House Type	Envelope	Mechanicals	Ventilation
T	**TL**	**O**	**EE**	**H**
T - Toronto	TL - Large Two Storey	O - OBC	EE - electric space and dhw	F - Fan(s)
S - Sault Ste. Marie	TS - Small Two Storey	N - NECH	AS - electric air source heat pump and dhw	H - HRV
	BS - Small Bungalow		GS - electric ground source heat pump and dhw	
	SD - Semi Detached		MO - minimum efficiency oil space and dhw	
	RE - End Row		MP - minimum efficiency propane space and dhw	
	RI - Interior Row		MG - mid - efficiency natural gas space and dhw	
			HG - high efficiency natural gas space and dhw	

Physical Characteristics Large Two Storey Benchmark House (Floor Area 2100 ft²)			
Component		**m²**	**ft²**
Ceiling		106.8	1149.59
Main Walls		183.6	1976.25
Windows	South North East West	14.75 8.59 0.46 2.74	158.77 92.46 4.95 29.49
Doors		3.71	39.93
Basement Walls	Above Grade 0.6 m Below Grade Lower Perimeter	18.7 24.5 70.2	201.28 263.72 755.63
Basement Slab	1 m Perimeter Centre	35.3 59.2	379.97 637.22
Volume		**781.32 m³**	**27586.54 ³**
Liveable Floor Area		**196.0 m²**	**2109.73 ²**



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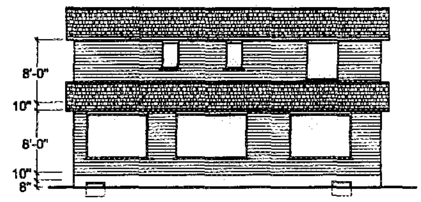

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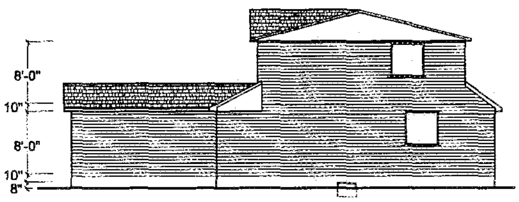

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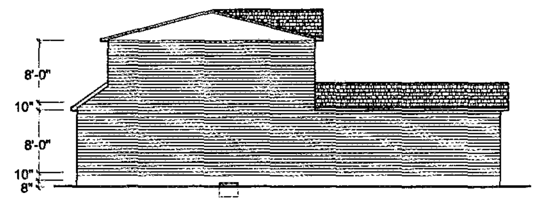

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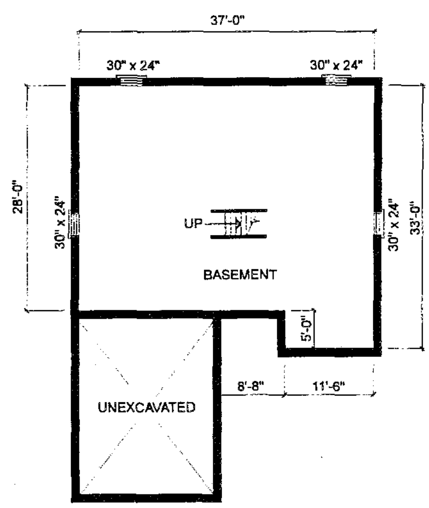
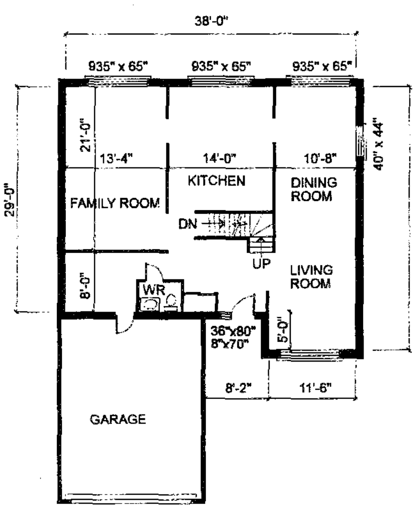


BASEMENT FLOOR PLAN



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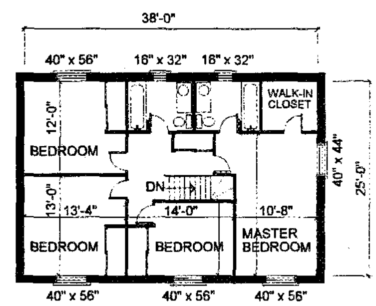
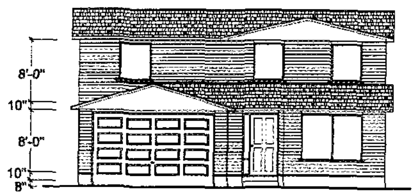


SECOND FLOOR PLAN

TWO STOREY HOUSE

FLOOR AREA 2100 ft^2 (196 m^2)



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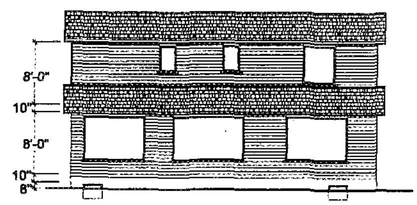

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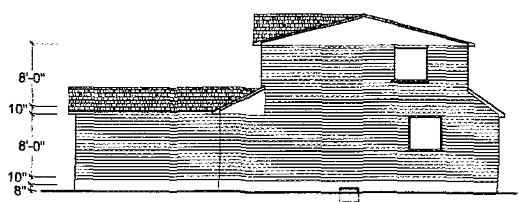

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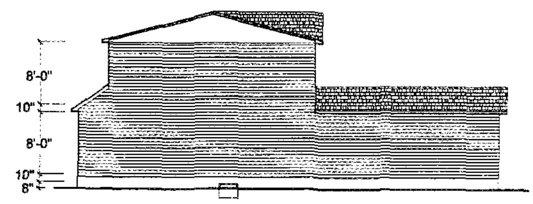

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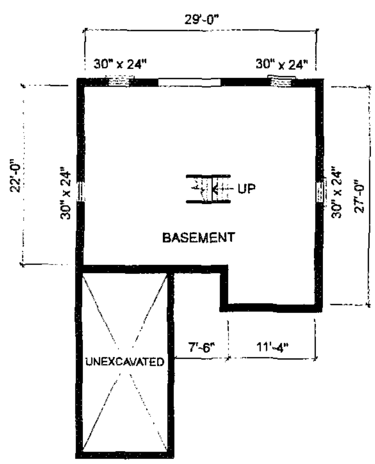

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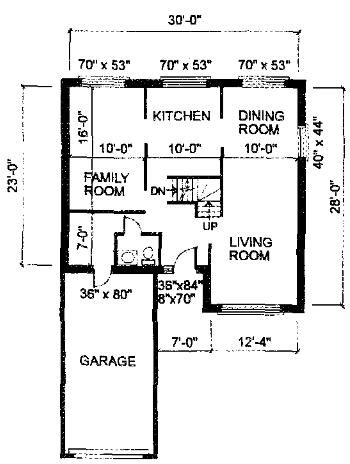

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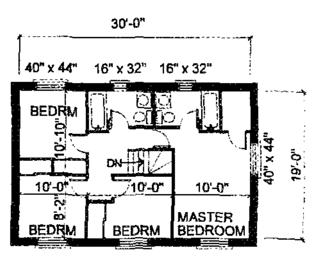


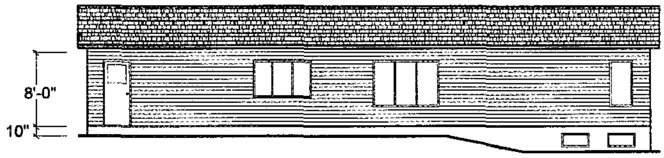
SECOND FLOOR PLAN

TWO STOREY HOUSE

N

FLOOR AREA 1320 ft^2 (123 m^2)

Physical Characteristics Small Two Storey Benchmark House (Floor Area 1320 ft²)			
Component		**m²**	**ft²**
Ceiling		69.9	752.4
Main Walls		145.5	1566.15
Windows	South North East West	9.79 7.68 0.46 2.74	105.38 82.67 4.95 29.49
Doors		3.8	40.9
Basement Walls	Above Grade 0.6 m Below Grade Lower Perimeter	14.8 19.3 56.0	159.30 207.74 602.78
Basement Slab	1 m Perimeter Centre	27.5 37.1	296.01 399.34
Volume		**491.1 m³**	**17339.57 ft³**
Liveable Floor Area		**123.0 m²**	**1323.96 ft²**



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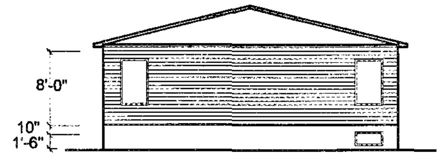

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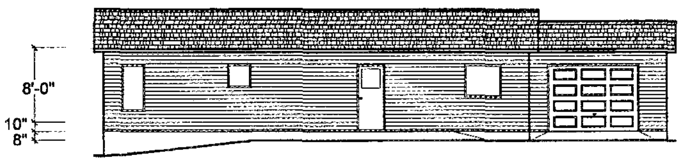

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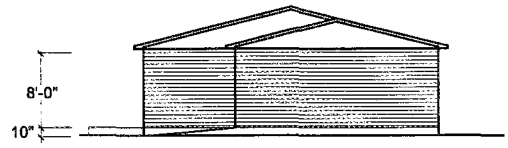
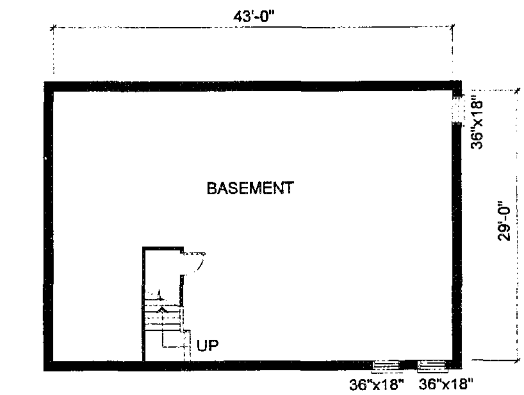
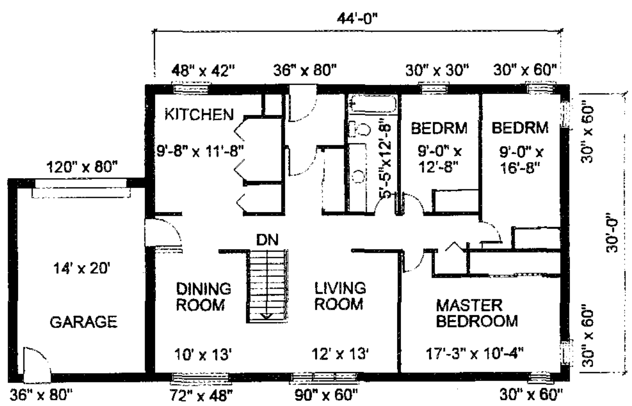


RIGHT ELEVATION



BASEMENT FLOOR PLAN

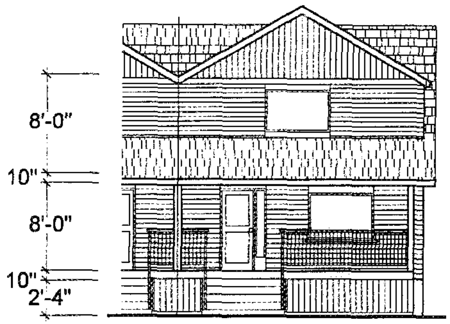


MAIN FLOOR PLAN

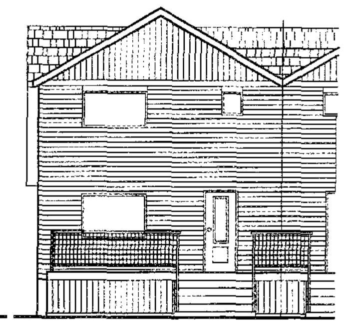
ONE STOREY HOUSE

FLOOR AREA 1320 ft^2 (122 m^2)

Physical Characteristics Small Bungalow Benchmark House (Floor Area 1320 ft^2)			
Component		**m^2**	**ft^2**
Ceiling		122.63	1320
Main Walls		92.88	999.75
Windows	South	8.45	91.00
	East	2.74	29.50
	North	3.04	32.75
Doors		3.72	40
Basement Walls	Above Grade	20.91	225.05
	0.6 m Below Grade	27.50	296.00
	Lower Perimeter	73.28	788.80
Basement Slab	1 m Perimeter	37.90	408.00
	Centre	84.73	912.00
Volume		**629.09 m^3**	**22216 ft^3**
Liveable Floor Area		**122.63 m^2**	**1320 ft^2**



FRONT ELEVATION



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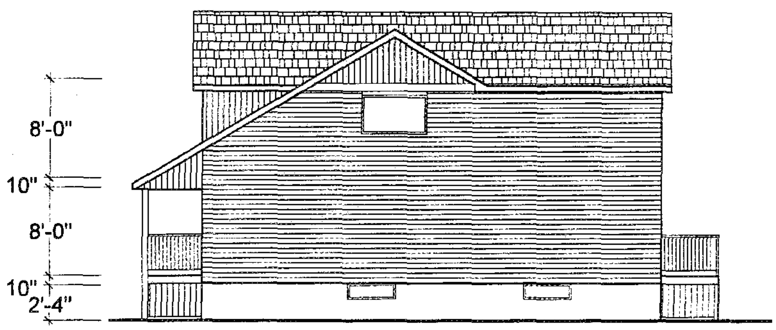

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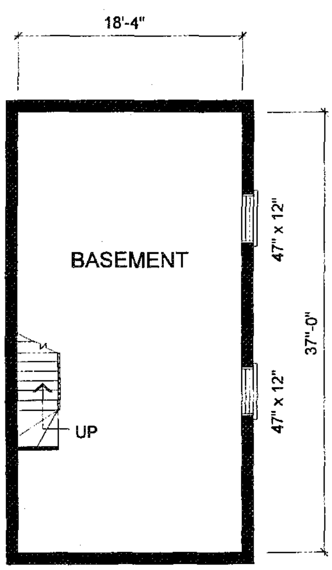
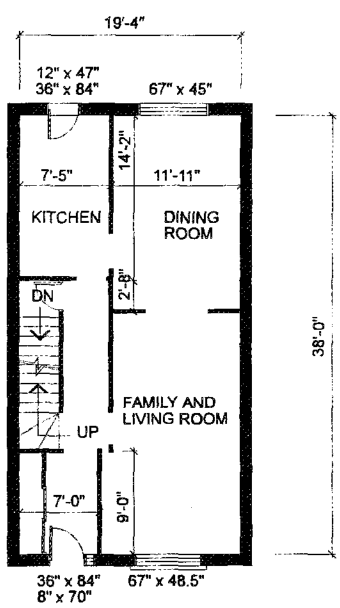
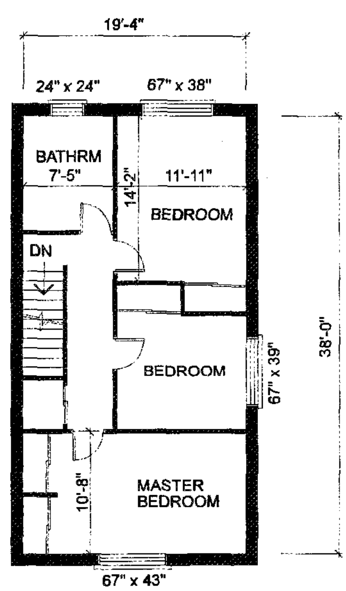


BASEMENT PLAN



FIRST FLOOR PLAN

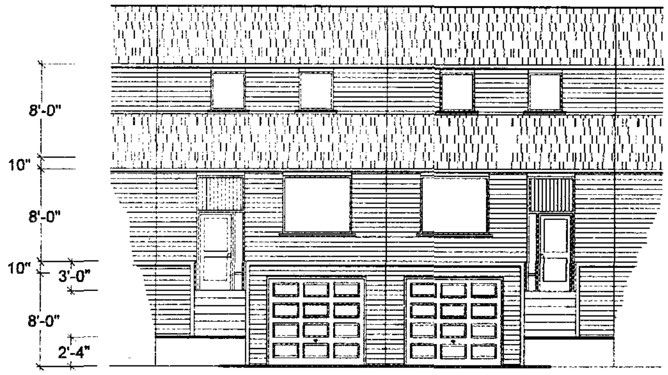


SECOND FLOOR PLAN

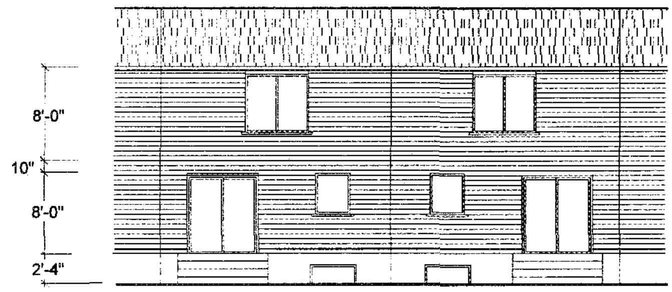
SEMI-DETACHED HOUSE

FLOOR AREA 1470 ft^2 (137 m^2)

Physical Characteristics Semi-Detached Benchmark House (Floor Area 1470 ft²)			
Component		**m²**	**ft²**
Ceiling		68.44	736.68
Main Walls		106.2	1143.13
Windows	South North West	4.33 4.33 2.42	46.61 46.61 26.04
Doors		3.52	37.89
Basement Walls	Above Grade 0.6 m Below Grade Lower Perimeter	20.66 13.5 25.65	222.38 145.31 276.09
Basement Slab	1 m Perimeter Centre	18.63 44.67	200.53 480.82
Volume		**521.3 m³**	**18405.86 ft³**
Liveable Floor Area		**137.0 m²**	**1474.66 ft²**



FRONT ELEVATION



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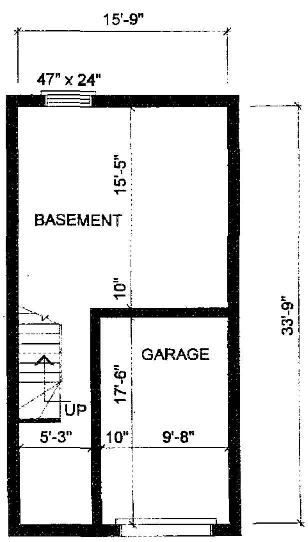
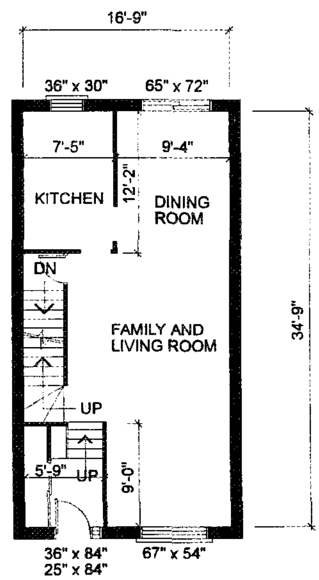
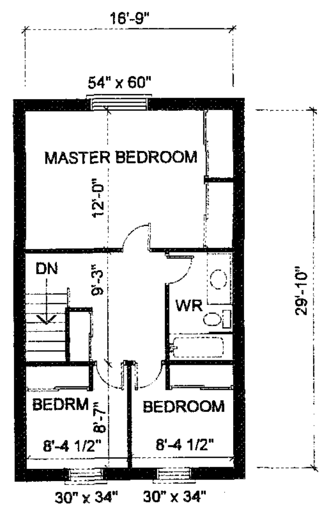


BASEMENT PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

ROW HOUSE

FLOOR AREA 1080 ft² (100 m²)

Physical Characteristics Interior and Exterior Row Benchmark House (Floor Area 1470 ft²)			
Component		**m²**	**ft²**
Ceiling		53.3/(54.06)	573.72/(581.89)
Main Walls		41.87/(98.71)	450.68/(1062.51)
Exposed Floors		17.11	184.17
Windows	South North	6.16 4.31	66.31 46.39
Doors		1.93	20.77
Basement Walls	Above Grade 0.6 m Below Grade Lower Perimeter	25.97/(37.38) 2.88/(5.16) 7.78/(19.34)	279.54/(402.35) 31.00/(55.54) 83.74/(208.17)
Basement Slab	1 m Perimeter Centre	13.68/(20.16) 17.82/(11.13)	147.25/(217.00) 191.81/(119.80)
Volume		**341.58 m³**	**12060.38 ft³**
Liveable Floor Area		**100.51 m²**	**1081.88 ft²**
Note: All data for Interior Units, () indicates End Units			

Appendix II

ENVELOPE CAPITAL COSTS - OBC - ZONE 1

1993 OBC ZONE 1 ELECTRIC, AS & GS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 7.0 (R-40) ceiling insulation	61.29	106.8	6546	69.9	4284	122.63	7516	68.44	4195	54.06	3313	53.3	3267
RSI 4.7 (R-27) wall insulation	90.31	183.3	16554	145.3	13122	92.88	8388	106.4	9609	86.96	7853	40.63	3669
RSI 3.25 (R-19) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	40655	COST	31229	COST	31391	COST	22341	COST	19791	COST	13079

1993 OBC ZONE 1 NATURAL GAS, OIL, PROPANE		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 5.4 (R-31) ceiling insulation*	59.27	106.8	6330	69.9	4143	122.63	7268	68.44	4056	54.06	3204	53.3	3159
RSI 3.25 (R-19) wall insulation	78.68	183.3	14422	145.3	11432	92.88	7308	106.4	8372	86.96	6842	40.63	3197
RSI 2.11 (R-12) basement insulation	93.32	111.5	10405	88.2	8231	121.69	11356	59.08	5513	61.15	5707	35.9	3350
RSI 0.39 (R-2.2) dg windows	231.84	26.62	6172	20.8	4822	14.23	3299	11.02	2555	10.55	2446	10.55	2446
		COST	37329	COST	28628	COST	29231	COST	20496	COST	18199	COST	12152

* NECH RSI 5.6 (R-32) unit cost data applied.

ENVELOPE CAPITAL COSTS - NECH - ZONE A

1995 NECH ZONE A ELECTRIC, OTHER		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 8.8 (R-50) ceiling insulation	63.9	106.8	6825	69.9	4467	122.63	7836	68.44	4373	54.06	3454	53.3	3406
RSI 4.7 (R-27) wall insulation	90.31	183.3	16554	145.3	13122	92.88	8388	106.4	9609	86.96	7853	40.63	3669
RSI 3.25 (R-19) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.53 (R-3.0) DG low-e argon windows	264.96	26.62	7053	20.8	5511	14.23	3770	11.02	2920	10.55	2795	10.55	2795
		COST	41392	COST	31770	COST	31957	COST	22710	COST	20114	COST	13399

1995 NECH ZONE A OIL/PROPANE, AS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 7.0 (R-40) ceiling insulation	61.29	106.8	6546	69.9	4284	122.63	7516	68.44	4195	54.06	3313	53.3	3267
RSI 3.25 (R-19) wall insulation	78.68	183.3	14422	145.3	11432	92.88	7308	106.4	8372	86.96	6842	40.63	3197
RSI 3.5 (R-20) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	38523	COST	29539	COST	30311	COST	21104	COST	18780	COST	12606

1995 NECH ZONE A NATURAL GAS & GS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 5.6 (R-32) ceiling insulation	59.27	106.8	6330	69.9	4143	122.63	7268	68.44	4056	54.06	3204	53.3	3159
RSI 3.0 (R-17) wall insulation	78.11	183.3	14318	145.3	11349	92.88	7255	106.4	8311	86.96	6792	40.63	3174
RSI 2.11 (R-12) basement insulation	93.32	111.5	10405	88.2	8231	121.69	11356	59.08	5513	61.15	5707	35.9	3350
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	37648	COST	28876	COST	29405	COST	20611	COST	18317	COST	12297

ENVELOPE CAPITAL COSTS - OBC - ZONE 2

1993 OBC ZONE 2 ELECTRIC, AS & GS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 7.0 (R-40) ceiling insulation	61.29	106.8	6546	69.9	4284	122.63	7516	68.44	4195	54.06	3313	53.3	3267
RSI 4.7 (R-27) wall insulation	90.31	183.3	16554	145.3	13122	92.88	8388	106.4	9609	86.96	7853	40.63	3669
RSI 3.25 (R-19) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	40655	COST	31229	COST	31391	COST	22341	COST	19791	COST	13079

1993 OBC ZONE 2 NATURAL GAS, OIL, PROPANE		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 6.7 (R-38) ceiling insulation	60.86	106.8	6500	69.9	4254	122.63	7463	68.44	4165	54.06	3290	53.3	3244
RSI 3.87 (R-22) wall insulation	86.28	183.3	15815	145.3	12536	92.88	8014	106.4	9180	86.96	7503	40.63	3506
RSI 2.11 (R-12) basement insulation	93.32	111.5	10405	88.2	8231	121.69	11356	59.08	5513	61.15	5707	35.9	3350
RSI 0.39 (R-2.2) dg windows	231.84	26.62	6172	20.8	4822	14.23	3299	11.02	2555	10.55	2446	10.55	2446
		COST	38892	COST	29844	COST	30132	COST	21414	COST	18945	COST	12545

ENVELOPE CAPITAL COSTS - NECH - ZONE B

1995 NECH ZONE B ELECTRIC, OTHER		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 10.6 (R-60) ceiling insulation	66.49	106.8	7101	69.9	4648	122.63	8154	68.44	4551	54.06	3594	53.3	3544
RSI 5.1 (R-29) wall insulation	92.03	183.3	16869	145.3	13372	92.88	8548	106.4	9792	86.96	8003	40.63	3739
RSI 3.25 (R-19) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.53 (R-3.0) DG low-e argon windows	264.96	26.62	7053	20.8	5511	14.23	3770	11.02	2920	10.55	2795	10.55	2795
		COST	41984	COST	32201	COST	32434	COST	23070	COST	20404	COST	13607

1995 NECH ZONE B OIL/PROPANE, AS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 8.8 (R-50) ceiling insulation	63.9	106.8	6825	69.9	4467	122.63	7836	68.44	4373	54.06	3454	53.3	3406
RSI 4.6 (R-26) wall insulation	87.09	183.3	15964	145.3	12654	92.88	8089	106.4	9266	86.96	7573	40.63	3538
RSI 3.5 (R-20) basement insulation	98.3	111.5	10960	88.2	8670	121.69	11962	59.08	5808	61.15	6011	35.9	3529
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	40343	COST	30944	COST	31412	COST	22177	COST	19652	COST	13087

1995 NECH ZONE B NATURAL GAS & GS HP		LARGE 2-STOREY		SMALL 2-STOREY		SMALL BUNGALOW		SEMI-DETACHED		EXTERIOR ROW		INTERIOR ROW	
	UNIT COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST	UNITS	COST
RSI 7.0 (R-40) ceiling insulation	61.29	106.8	6546	69.9	4284	122.63	7516	68.44	4195	54.06	3313	53.3	3267
RSI 3.4 (R-19.5) wall insulation	82.15	183.3	15058	145.3	11936	92.88	7630	106.4	8741	86.96	7144	40.63	3338
RSI 2.11 (R-12) basement insulation	93.32	111.5	10405	88.2	8231	121.69	11356	59.08	5513	61.15	5707	35.9	3350
RSI 0.50 (R-2.8) DG low-e windows	247.74	26.62	6595	20.8	5153	14.23	3525	11.02	2730	10.55	2614	10.55	2614
		COST	38604	COST	29604	COST	30028	COST	21179	COST	18777	COST	12568

MECHANICAL SYSTEMS CAPITAL COSTS

		LARGE 2-STOREY			SMALL 2-STOREY			SMALL BUNGALOW			SEMI-DETACHED			EXTERIOR ROW			INTERIOR ROW		
	UNIT COST	UNITS	COST	SALE	UNITS	COST	SALE	UNITS	COST	SALE	UNITS	COST	SALE	UNITS	COST	SALE	UNITS	COST	SALE
Baseboard Electric	80	16	1280	1739	13	1040	1413	13	1040	1413	14	1120	1522	11	880	1195	11	880	1195
Electrical Thermal Storage	690	7	4830	5047	6	4140	4326	6	4140	4326	6	4140	4326	6	4140	4326	6	4140	4326
Forced Air Electric	2685	1	2685	3648	1	2460	3342	1	2460	3342	1	2460	3342	1	2460	3342	1	2460	3342
Air source heat pump	5565	1	5565	7560	1	5365	7288	1	5365	7288	1	5365	7288	1	5365	7288	1	5365	7288
Ground source heat pump	12745	1	12745	17314	1	12745	17314	1	12745	17314	1	12745	17314	1	12745	17314	1	12745	17314
Mid Efficiency Forced Air Gas/Propane	3525	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789
Hi Efficiency Forced Air Gas/Propane	4465	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066
Bi-valent Gas Heat Pump	6065	1	6065	8239	1	6065	8239	1	6065	8239	1	6065	8239	1	6065	8239	1	6065	8239
Mid Efficiency Forced Air Oil	3525	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789	1	3525	4789
Hi Efficiency Forced Air Oil	4465	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066	1	4465	6066
Unitary Air Conditioning	800	3	2400	3260	2	1600	2174	2	1600	2174	2	1600	2174	2	1600	2174	2	1600	2174
Central Air Conditioning	1950	1	1950	2649	1	1950	2649	1	1950	2649	1	1950	2649	1	1950	2649	1	1950	2649
Part 9 Exhaust Ventilation System	350	1	350	475	1	350	475	1	350	475	1	350	475	1	350	475	1	350	475
Minimum Efficiency HRV	800	1	800	1087	1	800	1087	1	800	1087	1	800	1087	1	800	1087	1	800	1087
High Efficiency HRV	1800	1	1800	2445	1	1800	2445	1	1800	2445	1	1800	2445	1	1800	2445	1	1800	2445
Electric DWH	250	1	250	340	1	250	340	1	250	340	1	250	340	1	250	340	1	250	340
Conventional Gas DWH	755	1	755	1026	1	755	1026	1	755	1026	1	755	1026	1	755	1026	1	755	1026
Mid Efficiency Gas DWH	1550	1	1550	2106	1	1550	2106	1	1550	2106	1	1550	2106	1	1550	2106	1	1550	2106

30% margin

4.5% GST

CAPITAL COSTS SUMMARY - OBC - ZONE 1

HOUSE ID	ENVELOPE	SPACE HEATING	SPACE COOLING	VENTILATION	DHW	LIGHTING & APPL.	TOTAL
TTLOEEH	$40,654.88	$3,647.57		$1,086.80			$45,389.26
TTLOASH	$40,654.88	$7,560.05		$1,086.80			$49,301.74
TTLOGSH	$40,654.88	$17,314.08		$1,086.80			$59,055.77
TTLOMOF	$37,328.84	$4,788.71		$475.48			$42,593.03
TTLOMPF	$37,328.84	$4,788.71		$475.48			$42,593.03
TTLOMGF	$37,328.84	$4,788.71		$475.48			$42,593.03
TTLOHGF	$37,328.84	$6,065.70		$475.48			$43,870.02
TTSOEEH	$31,229.27	$3,341.91		$1,086.80			$35,657.98
TTSOASH	$31,229.27	$7,288.35		$1,086.80			$39,604.42
TTSOGSH	$31,229.27	$17,314.08		$1,086.80			$49,630.15
TTSOMOF	$28,628.27	$4,788.71		$475.48			$33,892.46
TTSOMPF	$28,628.27	$4,788.71		$475.48			$33,892.46
TTSOMGF	$28,628.27	$4,788.71		$475.48			$33,892.46
TTSOHGF	$28,628.27	$6,065.70		$475.48			$35,169.45
TBSOEEH	$31,391.45	$3,341.91		$1,086.80			$35,820.16
TBSOASH	$31,391.45	$7,288.35		$1,086.80			$39,766.61
TBSOGSH	$31,391.45	$17,314.08		$1,086.80			$49,792.34
TBSOMOF	$29,231.27	$4,788.71		$475.48			$34,495.46
TBSOMPF	$29,231.27	$4,788.71		$475.48			$34,495.46
TBSOMGF	$29,231.27	$4,788.71		$475.48			$34,495.46
TBSOHGF	$29,231.27	$6,065.70		$475.48			$35,772.45
TSDOEEH	$22,341.33	$3,341.91		$1,086.80			$26,770.04
TSDOASH	$22,341.33	$7,288.35		$1,086.80			$30,716.48
TSDOGSH	$22,341.33	$17,314.08		$1,086.80			$40,742.21
TSDOMOF	$20,496.21	$4,788.71		$475.48			$25,760.40
TSDOMPF	$20,496.21	$4,788.71		$475.48			$25,760.40
TSDOMGF	$20,496.21	$4,788.71		$475.48			$25,760.40
TSDOHGF	$20,496.21	$6,065.70		$475.48			$27,037.39
TREOEEH	$19,791.40	$3,341.91		$1,086.80			$24,220.11
TREOASH	$19,791.40	$7,288.35		$1,086.80			$28,166.55
TREOGSH	$19,791.40	$17,314.08		$1,086.80			$38,192.28
TREOMOF	$18,198.58	$4,788.71		$475.48			$23,462.77
TREOMPF	$18,198.58	$4,788.71		$475.48			$23,462.77
TREOMGF	$18,198.58	$4,788.71		$475.48			$23,462.77
TREOHGF	$18,198.58	$6,065.70		$475.48			$24,739.76
TRIOEEH	$13,078.68	$3,341.91		$1,086.80			$17,507.39
TRIOASH	$13,078.68	$7,288.35		$1,086.80			$21,453.83
TRIOGSH	$13,078.68	$17,314.08		$1,086.80			$31,479.56
TRIOMOF	$12,151.96	$4,788.71		$475.48			$17,416.15
TRIOMPF	$12,151.96	$4,788.71		$475.48			$17,416.15
TRIOMGF	$12,151.96	$4,788.71		$475.48			$17,416.15
TRIOHGF	$12,151.96	$6,065.70		$475.48			$18,693.14

CAPITAL COSTS SUMMARY - NECH - ZONE A

HOUSE ID	ENVELOPE	SPACE HEATING	SPACE COOLING	VENTILATION	DHW	LIGHTING & APPL.	TOTAL
TTLNEEH	$41,392.03	$3,647.57		$1,086.80			$46,126.40
TTLNASH	$38,523.10	$7,560.05		$1,086.80			$47,169.96
TTLNGSF	$37,647.62	$17,314.08		$475.48			$55,437.18
TTLNMOH	$38,523.10	$4,788.71		$1,086.80			$44,398.62
TTLNMPH	$38,523.10	$4,788.71		$1,086.80			$44,398.62
TTLNMGF	$37,647.62	$4,788.71		$475.48			$42,911.81
TTLNHGF	$37,647.62	$6,065.70		$475.48			$44,188.80
TTSNEEH	$31,769.88	$3,341.91		$1,086.80			$36,198.59
TTSNASH	$29,539.43	$7,288.35		$1,086.80			$37,914.58
TTSNGSF	$28,876.17	$17,314.08		$475.48			$46,665.73
TTSNMOH	$29,539.43	$4,788.71		$1,086.80			$35,414.94
TTSNMPH	$29,539.43	$4,788.71		$1,086.80			$35,414.94
TTSNMGF	$28,876.17	$4,788.71		$475.48			$34,140.36
TTSNHGF	$28,876.17	$6,065.70		$475.48			$35,417.35
TBSNEEH	$31,956.56	$3,341.91		$1,086.80			$36,385.27
TBSNASH	$30,311.26	$7,288.35		$1,086.80			$38,686.41
TBSNGSF	$29,404.59	$17,314.08		$475.48			$47,194.15
TBSNMOH	$30,311.26	$4,788.71		$1,086.80			$36,186.77
TBSNMPH	$30,311.26	$4,788.71		$1,086.80			$36,186.77
TBSNMGF	$29,404.59	$4,788.71		$475.48			$34,668.78
TBSNHGF	$29,404.59	$6,065.70		$475.48			$35,945.77
TSDNEEH	$22,709.72	$3,341.91		$1,086.80			$27,138.43
TSDNASH	$21,103.90	$7,288.35		$1,086.80			$29,479.05
TSDNGSF	$20,610.78	$17,314.08		$475.48			$38,400.34
TSDNMOH	$21,103.90	$4,788.71		$1,086.80			$26,979.41
TSDNMPH	$21,103.90	$4,788.71		$1,086.80			$26,979.41
TSDNMGF	$20,610.78	$4,788.71		$475.48			$25,874.97
TSDNHGF	$20,610.78	$6,065.70		$475.48			$27,151.96
TRENEEH	$20,114.16	$3,341.91		$1,086.80			$24,542.87
TRENASH	$18,780.05	$7,288.35		$1,086.80			$27,155.20
TRENGSF	$18,316.76	$17,314.08		$475.48			$36,106.31
TRENMOH	$18,780.05	$4,788.71		$1,086.80			$24,655.56
TRENMPH	$18,780.05	$4,788.71		$1,086.80			$24,655.56
TRENMGF	$18,316.76	$4,788.71		$475.48			$23,580.94
TRENHGF	$18,316.76	$6,065.70		$475.48			$24,857.93
TRINEEH	$13,399.46	$3,341.91		$1,086.80			$17,828.17
TRINASH	$12,606.15	$7,288.35		$1,086.80			$20,981.30
TRINGSF	$12,296.55	$17,314.08		$475.48			$30,086.10
TRINMOH	$12,606.15	$4,788.71		$1,086.80			$18,481.66
TRINMPH	$12,606.15	$4,788.71		$1,086.80			$18,481.66
TRINMGF	$12,296.55	$4,788.71		$475.48			$17,560.73
TRINHGF	$12,296.55	$6,065.70		$475.48			$18,837.72

CAPITAL COSTS SUMMARY - OBC - ZONE 2

HOUSE ID	ENVELOPE	SPACE HEATING	SPACE COOLING	VENTILATION	DHW	LIGHTING & APPL.	TOTAL
STLOEEH	$40,654.88	$3,647.57		$1,086.80			$45,389.26
STLOASH	$40,654.88	$7,560.05		$1,086.80			$49,301.74
STLOGSH	$40,654.88	$17,314.08		$1,086.80			$59,055.77
STLOMOF	$38,891.73	$4,788.71		$475.48			$44,155.92
STLOMPF	$38,891.73	$4,788.71		$475.48			$44,155.92
STLOMGF	$38,891.73	$4,788.71		$475.48			$44,155.92
STLOHGF	$38,891.73	$6,065.70		$475.48			$45,432.91
STSOEEH	$31,229.27	$3,341.91		$1,086.80			$35,657.98
STSOASH	$31,229.27	$7,288.35		$1,086.80			$39,604.42
STSOGSH	$31,229.27	$17,314.08		$1,086.80			$49,630.15
STSOMOF	$29,843.69	$4,788.71		$475.48			$35,107.88
STSOMPF	$29,843.69	$4,788.71		$475.48			$35,107.88
STSOMGF	$29,843.69	$4,788.71		$475.48			$35,107.88
STSOHGF	$29,843.69	$6,065.70		$475.48			$36,384.87
SBSOEEH	$31,391.45	$3,341.91		$1,086.80			$35,820.16
SBSOASH	$31,391.45	$7,288.35		$1,086.80			$39,766.61
SBSOGSH	$31,391.45	$17,314.08		$1,086.80			$49,792.34
SBSOMOF	$30,132.14	$4,788.71		$475.48			$35,396.33
SBSOMPF	$30,132.14	$4,788.71		$475.48			$35,396.33
SBSOMGF	$30,132.14	$4,788.71		$475.48			$35,396.33
SBSOHGF	$30,132.14	$6,065.70		$475.48			$36,673.32
SSDOEEH	$22,341.33	$3,341.91		$1,086.80			$26,770.04
SSDOASH	$22,341.33	$7,288.35		$1,086.80			$30,716.48
SSDOGSH	$22,341.33	$17,314.08		$1,086.80			$40,742.21
SSDOMOF	$21,413.67	$4,788.71		$475.48			$26,677.86
SSDOMPF	$21,413.67	$4,788.71		$475.48			$26,677.86
SSDOMGF	$21,413.67	$4,788.71		$475.48			$26,677.86
SSDOHGF	$21,413.67	$6,065.70		$475.48			$27,954.85
SREOEEH	$19,791.40	$3,341.91		$1,086.80			$24,220.11
SREOASH	$19,791.40	$7,288.35		$1,086.80			$28,166.55
SREOGSH	$19,791.40	$17,314.08		$1,086.80			$38,192.28
SREOMOF	$18,945.43	$4,788.71		$475.48			$24,209.62
SREOMPF	$18,945.43	$4,788.71		$475.48			$24,209.62
SREOMGF	$18,945.43	$4,788.71		$475.48			$24,209.62
SREOHGF	$18,945.43	$6,065.70		$475.48			$25,486.61
SRIOEEH	$13,078.68	$3,341.91		$1,086.80			$17,507.39
SRIOASH	$13,078.68	$7,288.35		$1,086.80			$21,453.83
SRIOGSH	$13,078.68	$17,314.08		$1,086.80			$31,479.56
SRIOMOF	$12,545.49	$4,788.71		$475.48			$17,809.68
SRIOMPF	$12,545.49	$4,788.71		$475.48			$17,809.68
SRIOMGF	$12,545.49	$4,788.71		$475.48			$17,809.68
SRIOHGF	$12,545.49	$6,065.70		$475.48			$19,086.67

CAPITAL COSTS SUMMARY - NECH - ZONE B

HOUSE ID	ENVELOPE	SPACE HEATING	SPACE COOLING	VENTILATION	DHW	LIGHTING & APPL.	TOTAL
STLNEEH	$41,983.92	$3,647.57		$1,086.80			$46,718.29
STLNASH	$40,343.41	$7,560.05		$1,086.80			$48,990.26
STLNGSH	$38,603.89	$17,314.08		$1,086.80			$57,004.77
STLNMOH	$40,343.41	$4,788.71		$1,086.80			$46,218.92
STLNMPH	$40,343.41	$4,788.71		$1,086.80			$46,218.92
STLNMGH	$38,603.89	$4,788.71		$1,086.80			$44,479.40
STLNHGH	$38,603.89	$6,065.70		$1,086.80			$45,756.39
STSNEEH	$32,200.84	$3,341.91		$1,086.80			$36,629.55
STSNASH	$30,943.84	$7,288.35		$1,086.80			$39,318.99
STSNGSH	$29,604.38	$17,314.08		$1,086.80			$48,005.26
STSNMOH	$30,943.84	$4,788.71		$1,086.80			$36,819.35
STSNMPH	$30,943.84	$4,788.71		$1,086.80			$36,819.35
STSNMGH	$29,604.38	$4,788.71		$1,086.80			$35,479.89
STSNHGH	$29,604.38	$6,065.70		$1,086.80			$36,756.88
SBSNEEH	$32,433.92	$3,341.91		$1,086.80			$36,862.63
SBSNASH	$31,412.44	$7,288.35		$1,086.80			$39,787.60
SBSNGSH	$30,027.54	$17,314.08		$1,086.80			$48,428.42
SBSNMOH	$31,412.44	$4,788.71		$1,086.80			$37,287.96
SBSNMPH	$31,412.44	$4,788.71		$1,086.80			$37,287.96
SBSNMGH	$30,027.54	$4,788.71		$1,086.80			$35,903.05
SBSNHGH	$30,027.54	$6,065.70		$1,086.80			$37,180.04
SSDNEEH	$23,069.99	$3,341.91		$1,086.80			$27,498.70
SSDNASH	$22,177.35	$7,288.35		$1,086.80			$30,552.50
SSDNGSH	$21,178.89	$17,314.08		$1,086.80			$39,579.77
SSDNMOH	$22,177.35	$4,788.71		$1,086.80			$28,052.86
SSDNMPH	$22,177.35	$4,788.71		$1,086.80			$28,052.86
SSDNMGH	$21,178.89	$4,788.71		$1,086.80			$27,054.40
SSDNHGH	$21,178.89	$6,065.70		$1,086.80			$28,331.39
SRENEEH	$20,403.75	$3,341.91		$1,086.80			$24,832.46
SRENASH	$19,652.48	$7,288.35		$1,086.80			$28,027.63
SRENGSH	$18,777.28	$17,314.08		$1,086.80			$37,178.16
SRENMOH	$19,652.48	$4,788.71		$1,086.80			$25,527.99
SRENMPH	$19,652.48	$4,788.71		$1,086.80			$25,527.99
SRENMGH	$18,777.28	$4,788.71		$1,086.80			$24,652.79
SRENHGH	$18,777.28	$6,065.70		$1,086.80			$25,929.78
SRINEEH	$13,607.39	$3,341.91		$1,086.80			$18,036.10
SRINASH	$13,086.96	$7,288.35		$1,086.80			$21,462.12
SRINGSH	$12,568.36	$17,314.08		$1,086.80			$30,969.24
SRINMOH	$13,086.96	$4,788.71		$1,086.80			$18,962.48
SRINMPH	$13,086.96	$4,788.71		$1,086.80			$18,962.48
SRINMGH	$12,568.36	$4,788.71		$1,086.80			$18,443.87
SRINHGH	$12,568.36	$6,065.70		$1,086.80			$19,720.86

ANNUAL ENERGY CONSUMPTION - OBC - ZONE 1

	Space Heating				
HOUSE ID	ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	ANNUAL COST
TTLOEEH	31229	0	0	0	$783
TTLOASH	18290	0	0	0	$459
TTLOGSH	13672	0	0	0	$343
TTLOMOF	4643	0	60527	0	$728
TTLOMPF	4643	60527	0	0	$969
TTLOMGF	4643	0	0	60527	$476
TTLOHGF	4643	0	0	52457	$428
TTSOEEH	20784	0	0	0	$521
TTSOASH	13036	0	0	0	$327
TTSOGSH	10078	0	0	0	$253
TTSOMOF	4560	0	43521	0	$554
TTSOMPF	4560	43521	0	0	$727
TTSOMGF	4560	0	0	43521	$373
TTSOHGF	4560	0	0	37718	$338
TBSOEEH	26642	0	0	0	$668
TBSOASH	15831	0	0	0	$397
TBSOGSH	14304	0	0	0	$359
TBSOMOF	4680	0	51252	0	$635
TBSOMPF	4680	51252	0	0	$839
TBSOMGF	4680	0	0	51252	$422
TBSOHGF	4680	0	0	44418	$381
TSDOEEH	19661	0	0	0	$493
TSDOASH	12483	0	0	0	$313
TSDOGSH	9695	0	0	0	$243
TSDOMOF	4587	0	40378	0	$523
TSDOMPF	4587	40378	0	0	$684
TSDOMGF	4587	0	0	40378	$355
TSDOHGF	4587	0	0	34994	$323
TREOEEH	12851	0	0	0	$322
TREOASH	9050	0	0	0	$227
TREOGSH	7252	0	0	0	$182
TREOMOF	4438	0	30250	0	$417
TREOMPF	4438	30250	0	0	$537
TREOMGF	4438	0	0	30250	$291
TREOHGF	4438	0	0	26217	$267
TRIOEEH	8005	0	0	0	$201
TRIOASH	6494	0	0	0	$163
TRIOGSH	5514	0	0	0	$138
TRIOMOF	4234	0	19219	0	$300
TRIOMPF	4234	19219	0	0	$377
TRIOMGF	4234	0	0	19219	$220
TRIOHGF	4234	0	0	16656	$205

ANNUAL ENERGY CONSUMPTION - NECH - ZONE A

	Space Heating				
HOUSE ID	ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	ANNUAL COST
TTLNEEH	29975	0	0	0	$752
TTLNASH	21331	0	0	0	$535
TTLNGSF	19682	0	0	0	$494
TTLNMOH	4376	0	44483	0	$559
TTLNMPH	4376	44483	0	0	$736
TTLNMGF	4617	0	0	60598	$476
TTLNHGF	4617	0	0	52518	$428
TTSNEEH	19963	0	0	0	$501
TTSNASH	15272	0	0	0	$383
TTSNGSF	15976	0	0	0	$401
TTSNMOH	4236	0	28946	0	$399
TTSNMPH	4236	28946	0	0	$514
TTSNMGF	4558	0	0	43278	$371
TTSNHGF	4558	0	0	37508	$337
TBSNEEH	25263	0	0	0	$634
TBSNASH	17574	0	0	0	$441
TBSNGSF	18216	0	0	0	$457
TBSNMOH	4348	0	35058	0	$463
TBSNMPH	4348	35058	0	0	$603
TBSNMGF	4686	0	0	51449	$423
TBSNHGF	4686	0	0	44589	$382
TSDNEEH	18906	0	0	0	$474
TSDNASH	14184	0	0	0	$356
TSDNGSF	15277	0	0	0	$383
TSDNMOH	4234	0	26037	0	$369
TSDNMPH	4234	26037	0	0	$473
TSDNMGF	4591	0	0	40558	$356
TSDNHGF	4591	0	0	35150	$324
TRENEEH	12316	0	0	0	$309
TRENASH	10310	0	0	0	$259
TRENGSF	12582	0	0	0	$316
TRENMOH	4041	0	15944	0	$262
TRENMPH	4041	15944	0	0	$326
TRENMGF	4444	0	0	30518	$293
TRENHGF	4444	0	0	26449	$269
TRINEEH	7581	0	0	0	$190
TRINASH	6984	0	0	0	$175
TRINGSF	9408	0	0	0	$236
TRINMOH	3847	0	8053	0	$178
TRINMPH	3847	8053	0	0	$210
TRINMGF	4233	0	0	19102	$220
TRINHGF	4233	0	0	16555	$205

ANNUAL ENERGY CONSUMPTION - OBC - ZONE 2

	Space Heating				
HOUSE ID	ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	ANNUAL COST
STLOEEH	44534	0	0	0	$1,117
STLOASH	27037	0	0	0	$678
STLOGSH	18456	0	0	0	$463
STLOMOF	4964	0	75265	0	$885
STLOMPF	4964	75265	0	0	$1,184
STLOMGF	4964	0	0	75265	$572
STLOHGF	4964	0	0	65230	$512
STSOEEH	29973	0	0	0	$752
STSOASH	18701	0	0	0	$469
STSOGSH	13401	0	0	0	$336
STSOMOF	4880	0	53810	0	$666
STSOMPF	4880	53810	0	0	$880
STSOMGF	4880	0	0	53810	$442
STSOHGF	4880	0	0	46635	$399
SBSOEEH	39968	0	0	0	$1,003
SBSOASH	23920	0	0	0	$600
SBSOGSH	16958	0	0	0	$425
SBSOMOF	5004	0	63292	0	$765
SBSOMPF	5004	63292	0	0	$1,017
SBSOMGF	5004	0	0	63292	$501
SBSOHGF	5004	0	0	54853	$451
SSDOEEH	28185	0	0	0	$707
SSDOASH	17890	0	0	0	$449
SSDOGSH	12956	0	0	0	$325
SSDOMOF	4910	0	50647	0	$635
SSDOMPF	4910	50647	0	0	$836
SSDOMGF	4910	0	0	50647	$424
SSDOHGF	4910	0	0	43894	$384
SREOEEH	18635	0	0	0	$467
SREOASH	12714	0	0	0	$319
SREOGSH	9464	0	0	0	$237
SREOMOF	4756	0	37780	0	$501
SREOMPF	4756	37780	0	0	$651
SREOMGF	4756	0	0	37780	$344
SREOHGF	4756	0	0	32743	$314
SRIOEEH	11968	0	0	0	$300
SRIOASH	9104	0	0	0	$228
SRIOGSH	7087	0	0	0	$178
SRIOMOF	4555	0	24888	0	$366
SRIOMPF	4555	24888	0	0	$465
SRIOMGF	4555	0	0	24888	$262
SRIOHGF	4555	0	0	21570	$242

ANNUAL ENERGY CONSUMPTION - NECH - ZONE B

	Space Heating				
HOUSE ID	ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	ANNUAL COST
STLNEEH	40953	0	0	0	$1,027
STLNASH	26786	0	0	0	$672
STLNGSH	21781	0	0	0	$546
STLNMOH	4664	0	53951	0	$662
STLNMPH	4664	53951	0	0	$877
STLNMGH	4782	0	0	64428	$503
STLNHGH	4782	0	0	65838	$511
STSNEEH	27558	0	0	0	$691
STSNASH	18609	0	0	0	$467
STSNGSH	16202	0	0	0	$406
STSNMOH	4519	0	34421	0	$461
STSNMPH	4519	34421	0	0	$598
STSNMGH	4649	0	0	42884	$371
STSNHGH	4649	0	0	37149	$337
SBSNEEH	36429	0	0	0	$914
SBSNASH	23335	0	0	0	$585
SBSNGSH	17990	0	0	0	$451
SBSNMOH	4693	0	46470	0	$587
SBSNMPH	4693	46470	0	0	$772
SBSNMGH	4748	0	0	56898	$457
SBSNHGH	4748	0	0	49312	$412
SSDNEEH	25979	0	0	0	$652
SSDNASH	17685	0	0	0	$444
SSDNGSH	15153	0	0	0	$380
SSDNMOH	4528	0	32326	0	$440
SSDNMPH	4528	32326	0	0	$569
SSDNMGH	4644	0	0	38869	$347
SSDNHGH	4844	0	0	33686	$322
SRENEEH	17082	0	0	0	$428
SRENASH	12605	0	0	0	$316
SRENGSH	11655	0	0	0	$292
SRENMOH	4331	0	19782	0	$308
SRENMPH	4331	19782	0	0	$387
SRENMGH	4468	0	0	26452	$269
SRENHGH	4468	0	0	22925	$248
SRINEEH	10869	0	0	0	$273
SRINASH	8904	0	0	0	$223
SRINGSH	9909	0	0	0	$249
SRINMOH	4156	0	10388	0	$209
SRINMPH	4156	10388		0	$251
SRINMGH	4248	0	0	14438	$192
SRINHGH	4248	0	0	12513	$181

CAPITAL & ANNUAL OPERATING COST SUMMARY - ZONE 2/B

OBC			NECH		
HOUSE ID	CAPITAL COSTS($)	OPERATING COSTS ($)	HOUSE ID	CAPITAL COSTS($)	OPERATING COSTS ($)
STLOEEH	$45,389	$1,117	STLNEEH	$46,718	$1,027
STLOASH	$49,302	$678	STLNASH	$48,990	$672
STLOGSH	$59,056	$463	STLNGSH	$57,005	$546
STLOMOF	$44,156	$885	STLNMOH	$46,219	$662
STLOMPF	$44,156	$1,184	STLNMPH	$46,219	$877
STLOMGF	$44,156	$572	STLNMGH	$44,479	$503
STLOHGF	$45,433	$512	STLNHGH	$45,756	$511
STSOEEH	$35,658	$752	STSNEEH	$36,630	$691
STSOASH	$39,604	$469	STSNASH	$39,319	$467
STSOGSH	$49,630	$336	STSNGSH	$48,005	$406
STSOMOF	$35,108	$666	STSNMOH	$36,819	$461
STSOMPF	$35,108	$880	STSNMPH	$36,819	$598
STSOMGF	$35,108	$442	STSNMGH	$35,480	$371
STSOHGF	$36,385	$399	STSNHGH	$36,757	$337
SBSOEEH	$35,820	$1,003	SBSNEEH	$36,863	$914
SBSOASH	$39,767	$600	SBSNASH	$39,788	$585
SBSOGSH	$49,792	$425	SBSNGSH	$48,428	$451
SBSOMOF	$35,396	$765	SBSNMOH	$37,288	$587
SBSOMPF	$35,396	$1,017	SBSNMPH	$37,288	$772
SBSOMGF	$35,396	$501	SBSNMGH	$35,903	$457
SBSOHGF	$36,673	$451	SBSNHGH	$37,180	$412
SSDOEEH	$26,770	$707	SSDNEEH	$27,499	$652
SSDOASH	$30,716	$449	SSDNASH	$30,553	$444
SSDOGSH	$40,742	$325	SSDNGSH	$39,580	$380
SSDOMOF	$26,678	$635	SSDNMOH	$28,053	$440
SSDOMPF	$26,678	$836	SSDNMPH	$28,053	$569
SSDOMGF	$26,678	$424	SSDNMGH	$27,054	$347
SSDOHGF	$27,955	$384	SSDNHGH	$28,331	$322
SREOEEH	$24,220	$467	SRENEEH	$24,832	$428
SREOASH	$28,167	$319	SRENASH	$28,028	$316
SREOGSH	$38,192	$237	SRENGSH	$37,178	$292
SREOMOF	$24,210	$501	SRENMOH	$25,528	$308
SREOMPF	$24,210	$651	SRENMPH	$25,528	$387
SREOMGF	$24,210	$344	SRENMGH	$24,653	$269
SREOHGF	$25,487	$314	SRENHGH	$25,930	$248
SRIOEEH	$17,507	$300	SRINEEH	$18,036	$273
SRIOASH	$21,454	$228	SRINASH	$21,462	$223
SRIOGSH	$31,480	$178	SRINGSH	$30,969	$249
SRIOMOF	$17,810	$366	SRINMOH	$18,962	$209
SRIOMPF	$17,810	$465	SRINMPH	$18,962	$251
SRIOMGF	$17,810	$262	SRINMGH	$18,444	$192
SRIOHGF	$19,087	$242	SRINHGH	$19,721	$181

Appendix III

ENERGY FORECAST MODELS

Last Update: January 1995

Economic Assumptions		1994 Base Prices for Energy		Operating Cost Factors	
INTEREST RATE (%)	9	ELECTRICITY	9.03 cents/kWh	Study Period	30 years
INFLATION RATE (%)	3	NATURAL GAS	5.94 $/GJ	ELECTRICITY	36.001 cents/MJ
DISCOUNT RATE (%)	6	OIL	10.1 $/GJ	NATURAL GAS	9.5012 cents/MJ
		PROPANE	14.08 $/GJ	OIL	15.802 cents/MJ
Present Worth Factor	0.174			PROPANE	22.029 cents/MJ

ONTARIO RETAIL PRICE FORECAST RESIDENTIAL SECTOR REAL 1994 PRICES

	ELECTRICITY PRICES		NATURAL GAS PRICES		LIGHT FUEL OIL PRICE		PROPANE PRICES	
	CENTS/MJ	%CH	CENTS/MJ	%CH	CENTS/MJ	%CH	CENTS/MJ	%CH
1994	2.508		0.594		1.010		1.408	
1995	2.518	0.40	0.602	1.40	1.022	1.20	1.425	1.20
1996	2.528	0.40	0.611	1.40	1.034	1.20	1.442	1.20
1997	2.539	0.40	0.619	1.40	1.047	1.20	1.459	1.20
1998	2.549	0.40	0.628	1.40	1.059	1.20	1.477	1.20
1999	2.559	0.40	0.637	1.40	1.072	1.20	1.495	1.20
2000	2.569	0.40	0.646	1.40	1.085	1.20	1.512	1.20
2001	2.579	0.40	0.655	1.40	1.098	1.20	1.531	1.20
2002	2.590	0.40	0.664	1.40	1.111	1.20	1.549	1.20
2003	2.600	0.40	0.673	1.40	1.124	1.20	1.568	1.20
2004	2.610	0.40	0.683	1.40	1.138	1.20	1.586	1.20
2005	2.621	0.40	0.692	1.40	1.152	1.20	1.605	1.20
2006	2.631	0.40	0.702	1.40	1.165	1.20	1.625	1.20
2007	2.642	0.40	0.712	1.40	1.179	1.20	1.644	1.20
2008	2.653	0.40	0.722	1.40	1.194	1.20	1.664	1.20
2009	2.663	0.40	0.732	1.40	1.208	1.20	1.684	1.20
2010	2.674	0.40	0.742	1.40	1.222	1.20	1.704	1.20
2011	2.684	0.40	0.752	1.40	1.237	1.20	1.725	1.20
2012	2.695	0.40	0.763	1.40	1.252	1.20	1.745	1.20
2013	2.706	0.40	0.774	1.40	1.267	1.20	1.766	1.20
2014	2.717	0.40	0.784	1.40	1.282	1.20	1.787	1.20
2015	2.728	0.40	0.795	1.40	1.298	1.20	1.809	1.20
2016	2.739	0.40	0.807	1.40	1.313	1.20	1.831	1.20
2017	2.750	0.40	0.818	1.40	1.329	1.20	1.852	1.20
2018	2.761	0.40	0.829	1.40	1.345	1.20	1.875	1.20
2019	2.772	0.40	0.841	1.40	1.361	1.20	1.897	1.20
2020	2.783	0.40	0.853	1.40	1.377	1.20	1.920	1.20
2021	2.794	0.40	0.865	1.40	1.394	1.20	1.943	1.20
2022	2.805	0.40	0.877	1.40	1.411	1.20	1.966	1.20
2023	2.816	0.40	0.889	1.40	1.427	1.20	1.990	1.20
2024	2.827	0.40 -	0.901	1.40	1.445	1.20	2.014	1.20
2025	2.839	0.40	0.914	1.40	1.462	1.20	2.038	1.20
2026	2.850	0.40	0.927	1.40	1.479	1.20	2.062	1.20
2027	2.862	0.40	0.940	1.40	1.497	1.20	2.087	1.20
2028	2.873	0.40	0.953	1.40	1.515	1.20	2.112	1.20
2029	2.884	0.40	0.966	1.40	1.533	1.20	2.138	1.20
2030	2.896	0.40	0.980	1.40	1.552	1.20	2.163	1.20
2031	2.908	0.40	0.994	1.40	1.570	1.20	2.189	1.20
2032	2.919	0.40	1.007	1.40	1.589	1.20	2.215	1.20
2033	2.931	0.40	1.022	1.40	1.608	1.20	2.242	1.20

NOTES: Gross Energy Content for light crude oil: 38.68 GJ/m3.

LIFE CYCLE COSTS SUMMARY - ZONE 1/A

OBC				NECH				
HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	SAVINGS
TTLOEEH	$45,389	$11,243	$56,632	TTLNEEH	$46,126	$10,791	$56,918	($286)
TTLOASH	$49,302	$6,584	$55,886	TTLNASH	$47,170	$7,679	$54,849	$1,037 N
TTLOGSH	$59,056	$4,922	$63,978	TTLNGSF	$55,437	$7,086	$62,523	$1,455 N
TTLOMOF	$42,593	$11,236	$53,829	TTLNMOH	$44,399	$8,605	$53,003	$826 N
TTLOMPF	$42,593	$15,005	$57,598	TTLNMPH	$44,399	$11,374	$55,773	$1,825 N
TTLOMGF	$42,593	$7,422	$50,015	TTLNMGF	$42,912	$7,420	$50,331	($316)
TTLOHGF	$43,870	$6,655	$50,526	TTLNHGF	$44,189	$6,652	$50,841	($315)
TTSOEEH	$35,658	$7,482	$43,140	TTSNEEH	$36,199	$7,187	$43,386	($245)
TTSOASH	$39,604	$4,693	$44,297	TTSNASH	$37,915	$5,498	$43,413	$885 N
TTSOGSH	$49,630	$3,628	$53,258	TTSNGSF	$46,666	$5,751	$52,417	$841 N
TTSOMOF	$33,892	$8,519	$42,411	TTSNMOH	$35,415	$6,099	$41,514	$897 N
TTSOMPF	$33,892	$11,229	$45,121	TTSNMPH	$35,415	$7,901	$43,316	$1,805 N
TTSOMGF	$33,892	$5,777	$39,669	TTSNMGF	$34,140	$5,753	$39,893	($224)
TTSOHGF	$35,169	$5,225	$40,395	TTSNHGF	$35,417	$5,204	$40,622	($227)
TBSOEEH	$35,820	$9,591	$45,411	TBSNEEH	$36,385	$9,095	$45,480	($69)
TBSOASH	$39,767	$5,699	$45,466	TBSNASH	$38,686	$6,327	$45,013	$453
TBSOGSH	$49,792	$5,150	$54,942	TBSNGSF	$47,194	$6,558	$53,752	$1,190 N
TBSOMOF	$34,495	$9,784	$44,279	TBSNMOH	$36,187	$7,105	$43,292	$987 N
TBSOMPF	$34,495	$12,975	$47,470	TBSNMPH	$36,187	$9,288	$45,475	$1,996 N
TBSOMGF	$34,495	$6,554	$41,050	TBSNMGF	$34,669	$6,575	$41,244	($194)
TBSOHGF	$35,772	$5,905	$41,678	TBSNHGF	$35,946	$5,923	$41,869	($192)
TSDOEEH	$26,770	$7,078	$33,848	TSDNEEH	$27,138	$6,806	$33,945	($96)
TSDOASH	$30,716	$4,494	$35,210	TSDNASH	$29,479	$5,106	$34,585	$625 N
TSDOGSH	$40,742	$3,490	$44,232	TSDNGSF	$38,400	$5,500	$43,900	$332
TSDOMOF	$25,760	$8,032	$33,792	TSDNMOH	$26,979	$5,639	$32,618	$1,174 N
TSDOMPF	$25,760	$10,546	$36,306	TSDNMPH	$26,979	$7,260	$34,239	$2,067 N
TSDOMGF	$25,760	$5,488	$31,248	TSDNMGF	$25,875	$5,506	$31,381	($133)
TSDOHGF	$27,037	$4,976	$32,014	TSDNHGF	$27,152	$4,992	$32,144	($131)
TREOEEH	$24,220	$4,626	$28,847	TRENEEH	$24,543	$4,434	$28,977	($130)
TREOASH	$28,167	$3,258	$31,425	TRENASH	$27,155	$3,712	$30,867	$557 N
TREOGSH	$38,192	$2,611	$40,803	TRENGSF	$36,106	$4,530	$40,636	$167
TREOMOF	$23,463	$6,378	$29,840	TRENMOH	$24,656	$3,974	$28,630	$1,211 N
TREOMPF	$23,463	$8,261	$31,724	TRENMPH	$24,656	$4,967	$29,623	$2,101 N
TREOMGF	$23,463	$4,472	$27,934	TRENMGF	$23,581	$4,500	$28,080	($146)
TREOHGF	$24,740	$4,089	$28,828	TRENHGF	$24,858	$4,113	$28,971	($143)
TRIOEEH	$17,507	$2,882	$20,389	TRINEEH	$17,828	$2,729	$20,557	($168)
TRIOASH	$21,454	$2,338	$23,792	TRINASH	$20,981	$2,514	$23,496	$296
TRIOGSH	$31,480	$1,985	$33,465	TRINGSF	$30,086	$3,387	$33,473	($8)
TRIOMOF	$17,416	$4,561	$21,977	TRINMOH	$18,482	$2,658	$21,139	$838 N
TRIOMPF	$17,416	$5,758	$23,174	TRINMPH	$18,482	$3,159	$21,641	$1,533 N
TRIOMGF	$17,416	$3,350	$20,766	TRINMGF	$17,561	$3,339	$20,900	($133)
TRIOHGF	$18,693	$3,107	$21,800	TRINHGF	$18,838	$3,097	$21,935	($135)

LIFE CYCLE COSTS SUMMARY - ZONE 2/B

OBC				NECH				
HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	SAVINGS
STLOEEH	$45,389	$16,033	$61,422	STLNEEH	$46,718	$14,743	$61,462	($40)
STLOASH	$49,302	$9,733	$59,035	STLNASH	$48,990	$9,643	$58,633	$402
STLOGSH	$59,056	$6,644	$65,700	STLNGSH	$57,005	$7,841	$64,846	$854 N
STLOMOF	$44,156	$13,680	$57,836	STLNMOH	$46,219	$10,204	$56,423	$1,413 N
STLOMPF	$44,156	$18,367	$62,523	STLNMPH	$46,219	$13,564	$59,783	$2,740 N
STLOMGF	$44,156	$8,938	$53,094	STLNMGH	$44,479	$7,843	$52,322	$772 N
STLOHGF	$45,433	$7,985	$53,418	STLNHGH	$45,756	$7,977	$53,733	($316)
STSOEEH	$35,658	$10,791	$46,449	STSNEEH	$36,630	$9,921	$46,551	($102)
STSOASH	$39,604	$6,732	$46,337	STSNASH	$39,319	$6,700	$46,019	$318
STSOGSH	$49,630	$4,824	$54,454	STSNGSH	$48,005	$5,833	$53,838	$616 N
STSOMOF	$35,108	$10,260	$45,368	STSNMOH	$36,819	$7,066	$43,886	$1,482 N
STSOMPF	$35,108	$13,610	$48,718	STSNMPH	$36,819	$9,210	$46,029	$2,689 N
STSOMGF	$35,108	$6,869	$41,977	STSNMGH	$35,480	$5,748	$41,228	$749 N
STSOHGF	$36,385	$6,188	$42,573	STSNHGH	$36,757	$5,203	$41,960	$612 N
SBSOEEH	$35,820	$14,389	$50,209	SBSNEEH	$36,863	$13,115	$49,977	$232
SBSOASH	$39,767	$8,611	$48,378	SBSNASH	$39,788	$8,401	$48,188	$189
SBSOGSH	$49,792	$6,105	$55,897	SBSNGSH	$48,428	$6,477	$54,905	$992 N
SBSOMOF	$35,396	$11,803	$47,199	SBSNMOH	$37,288	$9,033	$46,321	$878 N
SBSOMPF	$35,396	$15,744	$51,140	SBSNMPH	$37,288	$11,926	$49,214	$1,926 N
SBSOMGF	$35,396	$7,815	$43,211	SBSNMGH	$35,903	$7,115	$43,018	$193
SBSOHGF	$36,673	$7,013	$43,686	SBSNHGH	$37,180	$6,395	$43,575	$112
SSDOEEH	$26,770	$10,147	$36,917	SSDNEEH	$27,499	$9,353	$36,851	$66
SSDOASH	$30,716	$6,440	$37,157	SSDNASH	$30,553	$6,367	$36,919	$238
SSDOGSH	$40,742	$4,664	$45,407	SSDNGSH	$39,580	$5,455	$45,035	$372
SSDOMOF	$26,678	$9,771	$36,449	SSDNMOH	$28,053	$6,738	$34,791	$1,658 N
SSDOMPF	$26,678	$12,924	$39,602	SSDNMPH	$28,053	$8,751	$36,804	$2,798 N
SSDOMGF	$26,678	$6,580	$33,257	SSDNMGH	$27,054	$5,365	$32,419	$838 N
SSDOHGF	$27,955	$5,938	$33,893	SSDNHGH	$28,331	$4,944	$33,276	$617 N
SREOEEH	$24,220	$6,709	$30,929	SRENEEH	$24,832	$6,150	$30,982	($53)
SREOASH	$28,167	$4,577	$32,744	SRENASH	$28,028	$4,538	$32,565	$178
SREOGSH	$38,192	$3,407	$41,600	SRENGSH	$37,178	$4,196	$41,374	$225
SREOMOF	$24,210	$7,682	$31,892	SRENMOH	$25,528	$4,685	$30,213	$1,678 N
SREOMPF	$24,210	$10,034	$34,244	SRENMPH	$25,528	$5,917	$31,445	$2,799 N
SREOMGF	$24,210	$5,302	$29,511	SRENMGH	$24,653	$4,122	$28,775	$737 N
SREOHGF	$25,487	$4,823	$30,310	SRENHGH	$25,930	$3,787	$29,716	$593 N
SRIOEEH	$17,507	$4,309	$21,816	SRINEEH	$18,036	$3,913	$21,949	($133)
SRIOASH	$21,454	$3,278	$24,731	SRINASH	$21,462	$3,205	$24,668	$64
SRIOGSH	$31,480	$2,551	$34,031	SRINGSH	$30,969	$3,567	$34,537	($506) O
SRIOMOF	$17,810	$5,573	$23,382	SRINMOH	$18,962	$3,138	$22,100	$1,282 N
SRIOMPF	$17,810	$7,122	$24,932	SRINMPH	$18,962	$3,784	$22,747	$2,185 N
SRIOMGF	$17,810	$4,005	$21,814	SRINMGH	$18,444	$2,901	$21,345	$469
SRIOHGF	$19,087	$3,689	$22,776	SRINHGH	$19,721	$2,718	$22,439	$337

Appendix IV

ANNUAL ENERGY & EMISSIONS - OBC - ZONE 1

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
TTLOEEH	Energy	31228.920	0.000	0.000	0.000	31228.920	$370	$2,128
	CO2	8431.808	0.000	0.000	0.000	8431.808	$337	
	NOx	14.990	0.000	0.000	0.000	14.990	$3	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	40.598	0.000	0.000	0.000	40.598	$30	
	TSP	4.684	0.000	0.000	0.000	4.684	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.094	0.000	0.000	0.000	0.094	$0	
TTLOASH	Energy	18289.800	0.000	0.000	0.000	18289.800	$217	$1,246
	CO2	4938.246	0.000	0.000	0.000	4938.246	$198	
	NOx	8.779	0.000	0.000	0.000	8.779	$2	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	23.777	0.000	0.000	0.000	23.777	$17	
	TSP	2.743	0.000	0.000	0.000	2.743	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.055	0.000	0.000	0.000	0.055	$0	
TTLOGSH	Energy	13672.440	0.000	0.000	0.000	13672.440	$162	$932
	CO2	3691.559	0.000	0.000	0.000	3691.559	$148	
	NOx	6.563	0.000	0.000	0.000	6.563	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	17.774	0.000	0.000	0.000	17.774	$13	
	TSP	2.051	0.000	0.000	0.000	2.051	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.041	0.000	0.000	0.000	0.041	$0	
TTLOMOF	Energy	4642.920	0.000	60527.000	0.000	65169.920	$240	$1,379
	CO2	1253.588	0.000	4418.471	0.000	5672.059	$227	
	NOx	2.229	0.000	1.755	0.000	3.984	$1	
	CH4	0.000	0.000	0.303	0.000	0.303	$0	
	SOx	6.036	0.000	5.690	0.000	11.725	$9	
	TSP	0.696	0.000	0.484	0.000	1.181	$0	
	CO	0.000	0.000	0.787	0.000	0.787	$1	
	VOC	0.014	0.000	0.484	0.000	0.498	$3	
TTLOMPF	Energy	4642.920	60527.000	0.000	0.000	65169.920	$194	$1,112
	CO2	1253.588	3413.723	0.000	0.000	4667.311	$187	
	NOx	2.229	3.868	0.000	0.000	6.096	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	6.036	0.004	0.000	0.000	6.040	$4	
	TSP	0.696	0.114	0.000	0.000	0.810	$0	
	CO	0.000	0.341	0.000	0.000	0.341	$0	
	VOC	0.014	0.137	0.000	0.000	0.151	$1	
TTLOMGF	Energy	4642.920	0.000	0.000	60527.000	65169.920	$180	$1,036
	CO2	1253.588	0.000	0.000	3086.877	4340.465	$174	
	NOx	2.229	0.000	0.000	1.695	3.923	$1	
	CH4	0.000	0.000	0.000	0.061	0.061	$0	
	SOx	6.036	0.000	0.000	0.024	6.060	$4	
	TSP	0.696	0.000	0.000	0.363	1.060	$0	
	CO	0.000	0.000	0.000	0.424	0.424	$1	
	VOC	0.014	0.000	0.000	0.182	0.196	$1	
TTLOHGF	Energy	4642.920	0.000	0.000	52456.733	57099.653	$164	$940
	CO2	1253.588	0.000	0.000	2675.293	3928.882	$157	
	NOx	2.229	0.000	0.000	1.469	3.697	$1	
	CH4	0.000	0.000	0.000	0.052	0.052	$0	
	SOx	6.036	0.000	0.000	0.021	6.057	$4	
	TSP	0.696	0.000	0.000	0.315	1.011	$0	
	CO	0.000	0.000	0.000	0.367	0.367	$1	
	VOC	0.014	0.000	0.000	0.157	0.171	$1	

TTSOEEH	Energy	20784.240	0.000	0.000	0.000	20784.240	$247	$1,416
	CO2	5611.745	0.000	0.000	0.000	5611.745	$224	
	NOx	9.976	0.000	0.000	0.000	9.976	$2	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	27.020	0.000	0.000	0.000	27.020	$20	
	TSP	3.118	0.000	0.000	0.000	3.118	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.062	0.000	0.000	0.000	0.062	$0	
TTSOASH	Energy	13035.600	0.000	0.000	0.000	13035.600	$155	$888
	CO2	3519.612	0.000	0.000	0.000	3519.612	$141	
	NOx	6.257	0.000	0.000	0.000	6.257	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	16.946	0.000	0.000	0.000	16.946	$12	
	TSP	1.955	0.000	0.000	0.000	1.955	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.039	0.000	0.000	0.000	0.039	$0	
TTSOGSH	Energy	10077.840	0.000	0.000	0.000	10077.840	$120	$687
	CO2	2721.017	0.000	0.000	0.000	2721.017	$109	
	NOx	4.837	0.000	0.000	0.000	4.837	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	13.101	0.000	0.000	0.000	13.101	$10	
	TSP	1.512	0.000	0.000	0.000	1.512	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.030	0.000	0.000	0.000	0.030	$0	
TTSOMOF	Energy	4560.480	0.000	43521.000	0.000	48081.480	$187	$1,075
	CO2	1231.330	0.000	3177.033	0.000	4408.363	$176	
	NOx	2.189	0.000	1.262	0.000	3.451	$1	
	CH4	0.000	0.000	0.218	0.000	0.218	$0	
	SOx	5.929	0.000	4.091	0.000	10.020	$7	
	TSP	0.684	0.000	0.348	0.000	1.032	$0	
	CO	0.000	0.000	0.566	0.000	0.566	$1	
	VOC	0.014	0.000	0.348	0.000	0.362	$2	
TTSOMPF	Energy	4560.480	43521.000	0.000	0.000	48081.480	$154	$883
	CO2	1231.330	2454.584	0.000	0.000	3685.914	$147	
	NOx	2.189	2.781	0.000	0.000	4.970	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	5.929	0.003	0.000	0.000	5.931	$4	
	TSP	0.684	0.082	0.000	0.000	0.766	$0	
	CO	0.000	0.245	0.000	0.000	0.245	$0	
	VOC	0.014	0.098	0.000	0.000	0.112	$1	
TTSOMGF	Energy	4560.480	0.000	0.000	43521.000	48081.480	$144	$829
	CO2	1231.330	0.000	0.000	2219.571	3450.901	$138	
	NOx	2.189	0.000	0.000	1.219	3.408	$1	
	CH4	0.000	0.000	0.000	0.044	0.044	$0	
	SOx	5.929	0.000	0.000	0.017	5.946	$4	
	TSP	0.684	0.000	0.000	0.261	0.945	$0	
	CO	0.000	0.000	0.000	0.305	0.305	$0	
	VOC	0.014	0.000	0.000	0.131	0.144	$1	
TTSOHGF	Energy	4560.480	0.000	0.000	37718.200	42278.680	$132	$759
	CO2	1231.330	0.000	0.000	1923.628	3154.958	$126	
	NOx	2.189	0.000	0.000	1.056	3.245	$1	
	CH4	0.000	0.000	0.000	0.038	0.038	$0	
	SOx	5.929	0.000	0.000	0.015	5.944	$4	
	TSP	0.684	0.000	0.000	0.226	0.910	$0	
	CO	0.000	0.000	0.000	0.264	0.264	$0	
	VOC	0.014	0.000	0.000	0.113	0.127	$1	

TBSOEEH	Energy	26641.800	0.000	0.000	0.000	26641.800	$316	$1,815
	CO2	7193.286	0.000	0.000	0.000	7193.286	$288	
	NOx	12.788	0.000	0.000	0.000	12.788	$2	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	34.634	0.000	0.000	0.000	34.634	$25	
	TSP	3.996	0.000	0.000	0.000	3.996	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.080	0.000	0.000	0.000	0.080	$0	
TBSOASH	Energy	15831.360	0.000	0.000	0.000	15831.360	$188	$1,079
	CO2	4274.467	0.000	0.000	0.000	4274.467	$171	
	NOx	7.599	0.000	0.000	0.000	7.599	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	20.581	0.000	0.000	0.000	20.581	$15	
	TSP	2.375	0.000	0.000	0.000	2.375	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.047	0.000	0.000	0.000	0.047	$0	
TBSOGSH	Energy	14303.880	0.000	0.000	0.000	14303.880	$170	$975
	CO2	3862.048	0.000	0.000	0.000	3862.048	$154	
	NOx	6.866	0.000	0.000	0.000	6.866	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	18.595	0.000	0.000	0.000	18.595	$14	
	TSP	2.146	0.000	0.000	0.000	2.146	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.043	0.000	0.000	0.000	0.043	$0	
TBSOMOF	Energy	4680.000	0.000	51252.000	0.000	55932.000	$212	$1,219
	CO2	1263.600	0.000	3741.396	0.000	5004.996	$200	
	NOx	2.246	0.000	1.486	0.000	3.733	$1	
	CH4	0.000	0.000	0.256	0.000	0.256	$0	
	SOx	6.084	0.000	4.818	0.000	10.902	$8	
	TSP	0.702	0.000	0.410	0.000	1.112	$0	
	CO	0.000	0.000	0.666	0.000	0.666	$1	
	VOC	0.014	0.000	0.410	0.000	0.424	$2	
TBSOMPF	Energy	4680.000	51252.000	0.000	0.000	55932.000	$173	$992
	CO2	1263.600	2890.613	0.000	0.000	4154.213	$166	
	NOx	2.246	3.275	0.000	0.000	5.521	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	6.084	0.003	0.000	0.000	6.087	$4	
	TSP	0.702	0.096	0.000	0.000	0.798	$0	
	CO	0.000	0.289	0.000	0.000	0.289	$0	
	VOC	0.014	0.116	0.000	0.000	0.130	$1	
TBSOMGF	Energy	4680.000	0.000	0.000	51252.000	55932.000	$162	$929
	CO2	1263.600	0.000	0.000	2613.852	3877.452	$155	
	NOx	2.246	0.000	0.000	1.435	3.681	$1	
	CH4	0.000	0.000	0.000	0.051	0.051	$0	
	SOx	6.084	0.000	0.000	0.021	6.105	$4	
	TSP	0.702	0.000	0.000	0.308	1.010	$0	
	CO	0.000	0.000	0.000	0.359	0.359	$1	
	VOC	0.014	0.000	0.000	0.154	0.168	$1	
TBSOHGF	Energy	4680.000	0.000	0.000	44418.400	49098.400	$148	$847
	CO2	1263.600	0.000	0.000	2265.338	3528.938	$141	
	NOx	2.246	0.000	0.000	1.244	3.490	$1	
	CH4	0.000	0.000	0.000	0.044	0.044	$0	
	SOx	6.084	0.000	0.000	0.018	6.102	$4	
	TSP	0.702	0.000	0.000	0.267	0.969	$0	
	CO	0.000	0.000	0.000	0.311	0.311	$0	
	VOC	0.014	0.000	0.000	0.133	0.147	$1	

TSDOEEH	Energy	19661.040	0.000	0.000	0.000	19661.040	$233	$1,340
	CO2	5308.481	0.000	0.000	0.000	5308.481	$212	
	NOx	9.437	0.000	0.000	0.000	9.437	$2	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	25 559	0.000	0.000	0.000	25.559	$19	
	TSP	2.949	0.000	0.000	0.000	2.949	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.059	0.000	0.000	0.000	0.059	$0	
TSDOASH	Energy	12482.640	0.000	0.000	0.000	12482.640	$148	$850
	CO2	3370.313	0.000	0.000	0.000	3370.313	$135	
	NOx	5.992	0.000	0.000	0.000	5.992	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	16.227	0.000	0.000	0.000	16.227	$12	
	TSP	1.872	0.000	0.000	0.000	1.872	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.037	0.000	0.000	0.000	0.037	$0	
TSDOGSH	Energy	9694.800	0.000	0.000	0.000	9694.800	$115	$661
	CO2	2617.596	0.000	0.000	0.000	2617.596	$105	
	NOx	4.654	0.000	0.000	0.000	4.654	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	12.603	0.000	0.000	0.000	12.603	$9	
	TSP	1.454	0.000	0.000	0.000	1.454	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.029	0.000	0.000	0.000	0.029	$0	
TSDOMOF	Energy	4586.760	0.000	40378.000	0.000	44964.760	$178	$1,021
	CO2	1238.425	0.000	2947.594	0.000	4186.019	$167	
	NOx	2.202	0.000	1.171	0.000	3.373	$1	
	CH4	0.000	0.000	0.202	0.000	0.202	$0	
	SOx	5.963	0.000	3.796	0.000	9.758	$7	
	TSP	0.688	0.000	0.323	0.000	1.011	$0	
	CO	0.000	0.000	0.525	0.000	0.525	$1	
	VOC	0.014	0.000	0.323	0.000	0.337	$2	
TSDOMPF	Energy	4586.760	40378.000	0.000	0.000	44964.760	$147	$843
	CO2	1238.425	2277.319	0.000	0.000	3515.744	$141	
	NOx	2.202	2.580	0.000	0.000	4.782	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	5.963	0.003	0.000	0.000	5.965	$4	
	TSP	0.688	0.076	0.000	0.000	0.764	$0	
	CO	0.000	0.228	0.000	0.000	0.228	$0	
	VOC	0.014	0.091	0.000	0.000	0.105	$1	
TSDOMGF	Energy	4586.760	0.000	0.000	40378.000	44964.760	$138	$793
	CO2	1238.425	0.000	0.000	2059.278	3297.703	$132	
	NOx	2.202	0.000	0.000	1.131	3.332	$1	
	CH4	0.000	0.000	0.000	0.040	0.040	$0	
	SOx	5.963	0.000	0.000	0.016	5.979	$4	
	TSP	0.688	0.000	0.000	0.242	0.930	$0	
	CO	0.000	0.000	0.000	0.283	0.283	$0	
	VOC	0.014	0.000	0.000	0.121	0.135	$1	
TSDOHGF	Energy	4586.760	0.000	0.000	34994.267	39581.027	$127	$729
	CO2	1238.425	0.000	0.000	1784.708	3023.133	$121	
	NOx	2.202	0.000	0.000	0.980	3.181	$1	
	CH4	0.000	0.000	0.000	0.035	0.035	$0	
	SOx	5.963	0.000	0.000	0.014	5.977	$4	
	TSP	0.688	0.000	0.000	0.210	0.898	$0	
	CO	0.000	0.000	0.000	0.245	0.245	$0	
	VOC	0.014	0.000	0.000	0.105	0.119	$1	

TREOEEH	Energy	12850.920	0.000	0.000	0.000	12850.920	$152	$876
	CO2	3469.748	0.000	0.000	0.000	3469.748	$139	
	NOx	6.168	0.000	0.000	0.000	6.168	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	16.706	0.000	0.000	0.000	16.706	$12	
	TSP	1.928	0.000	0.000	0.000	1.928	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.039	0.000	0.000	0.000	0.039	$0	
TREOASH	Energy	9049.680	0.000	0.000	0.000	9049.680	$107	$617
	CO2	2443.414	0.000	0.000	0.000	2443.414	$98	
	NOx	4.344	0.000	0.000	0.000	4.344	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	11.765	0.000	0.000	0.000	11.765	$9	
	TSP	1.357	0.000	0.000	0.000	1.357	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.027	0.000	0.000	0.000	0.027	$0	
TREOGSH	Energy	7252.200	0.000	0.000	0.000	7252.200	$86	$494
	CO2	1958.094	0.000	0.000	0.000	1958.094	$78	
	NOx	3.481	0.000	0.000	0.000	3.481	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	9.428	0.000	0.000	0.000	9.428	$7	
	TSP	1.088	0.000	0.000	0.000	1.088	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.022	0.000	0.000	0.000	0.022	$0	
TREOMOF	Energy	4437.720	0.000	30250.000	0.000	34687.720	$145	$833
	CO2	1198.184	0.000	2208.250	0.000	3406.434	$136	
	NOx	2.130	0.000	0.877	0.000	3.007	$1	
	CH4	0.000	0.000	0.151	0.000	0.151	$0	
	SOx	5.769	0.000	2.844	0.000	8.613	$6	
	TSP	0.666	0.000	0.242	0.000	0.908	$0	
	CO	0.000	0.000	0.393	0.000	0.393	$1	
	VOC	0.013	0.000	0.242	0.000	0.255	$1	
TREOMPF	Energy	4437.720	30250.000	0.000	0.000	34687.720	$122	$700
	CO2	1198.184	1706.100	0.000	0.000	2904.284	$116	
	NOx	2.130	1.933	0.000	0.000	4.063	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	5.769	0.002	0.000	0.000	5.771	$4	
	TSP	0.666	0.057	0.000	0.000	0.723	$0	
	CO	0.000	0.171	0.000	0.000	0.171	$0	
	VOC	0.013	0.068	0.000	0.000	0.082	$0	
TREOMGF	Energy	4437.720	0.000	0.000	30250.000	34687.720	$115	$662
	CO2	1198.184	0.000	0.000	1542.750	2740.934	$110	
	NOx	2.130	0.000	0.000	0.847	2.977	$1	
	CH4	0.000	0.000	0.000	0.030	0.030	$0	
	SOx	5.769	0.000	0.000	0.012	5.781	$4	
	TSP	0.666	0.000	0.000	0.182	0.847	$0	
	CO	0.000	0.000	0.000	0.212	0.212	$0	
	VOC	0.013	0.000	0.000	0.091	0.104	$1	
TREOHGF	Energy	4437.720	0.000	0.000	26216.667	30654.387	$107	$614
	CO2	1198.184	0.000	0.000	1337.050	2535.234	$101	
	NOx	2.130	0.000	0.000	0.734	2.864	$1	
	CH4	0.000	0.000	0.000	0.026	0.026	$0	
	SOx	5.769	0.000	0.000	0.010	5.780	$4	
	TSP	0.666	0.000	0.000	0.157	0.823	$0	
	CO	0.000	0.000	0.000	0.184	0.184	$0	
	VOC	0.013	0.000	0.000	0.079	0.092	$0	

TRIOEEH	Energy	8004.600	0.000	0.000	0.000	8004.600	$95	$545
	CO2	2161.242	0.000	0.000	0.000	2161.242	$86	
	NOx	3.842	0.000	0.000	0.000	3.842	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	10.406	0.000	0.000	0.000	10.406	$8	
	TSP	1.201	0.000	0.000	0.000	1.201	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.024	0.000	0.000	0.000	0.024	$0	
TRIOASH	Energy	6493.680	0.000	0.000	0.000	6493.680	$77	$442
	CO2	1753.294	0.000	0.000	0.000	1753.294	$70	
	NOx	3.117	0.000	0.000	0.000	3.117	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	8.442	0.000	0.000	0.000	8.442	$6	
	TSP	0.974	0.000	0.000	0.000	0.974	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.019	0.000	0.000	0.000	0.019	$0	
TRIOGSH	Energy	5514.480	0.000	0.000	0.000	5514.480	$65	$376
	CO2	1488.910	0.000	0.000	0.000	1488.910	$60	
	NOx	2.647	0.000	0.000	0.000	2.647	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	7.169	0.000	0.000	0.000	7.169	$5	
	TSP	0.827	0.000	0.000	0.000	0.827	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.017	0.000	0.000	0.000	0.017	$0	
TRIOMOF	Energy	4233.600	0.000	19219.000	0.000	23452.600	$109	$626
	CO2	1143.072	0.000	1402.987	0.000	2546.059	$102	
	NOx	2.032	0.000	0.557	0.000	2.589	$0	
	CH4	0.000	0.000	0.096	0.000	0.096	$0	
	SOx	5.504	0.000	1.807	0.000	7.310	$5	
	TSP	0.635	0.000	0.154	0.000	0.789	$0	
	CO	0.000	0.000	0.250	0.000	0.250	$0	
	VOC	0.013	0.000	0.154	0.000	0.166	$1	
TRIOMPF	Energy	4233.600	19219.000	0.000	0.000	23452.600	$94	$541
	CO2	1143.072	1083.952	0.000	0.000	2227.024	$89	
	NOx	2.032	1.228	0.000	0.000	3.260	$1	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	5.504	0.001	0.000	0.000	5.505	$4	
	TSP	0.635	0.036	0.000	0.000	0.671	$0	
	CO	0.000	0.108	0.000	0.000	0.108	$0	
	VOC	0.013	0.043	0.000	0.000	0.056	$0	
TRIOMGF	Energy	4233.600	0.000	0.000	19219.000	23452.600	$90	$517
	CO2	1143.072	0.000	0.000	980.169	2123.241	$85	
	NOx	2.032	0.000	0.000	0.538	2.570	$0	
	CH4	0.000	0.000	0.000	0.019	0.019	$0	
	SOx	5.504	0.000	0.000	0.008	5.511	$4	
	TSP	0.635	0.000	0.000	0.115	0.750	$0	
	CO	0.000	0.000	0.000	0.135	0.135	$0	
	VOC	0.013	0.000	0.000	0.058	0.070	$0	
TRIOHGF	Energy	4233.600	0.000	0.000	16656.467	20890.067	$85	$487
	CO2	1143.072	0.000	0.000	849.480	1992.552	$80	
	NOx	2.032	0.000	0.000	0.466	2.499	$0	
	CH4	0.000	0.000	0.000	0.017	0.017	$0	
	SOx	5.504	0.000	0.000	0.007	5.510	$4	
	TSP	0.635	0.000	0.000	0.100	0.735	$0	
	CO	0.000	0.000	0.000	0.117	0.117	$0	
	VOC	0.013	0.000	0.000	0.050	0.063	$0	

ANNUAL ENERGY & EMISSIONS - OBC - ZONE 2

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
STLOEEH	Energy	44533.8	0.0	0.0	0.0	44533.8	$528	$3,034
	CO2	12024.1	0.0	0.0	0.0	12024.1	$481	
	NOx	21.4	0.0	0.0	0.0	21.4	$4	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	57.9	0.0	0.0	0.0	57.9	$42	
	TSP	6.7	0.0	0.0	0.0	6.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$1	
STLOASH	Energy	27036.7	0.0	0.0	0.0	27036.7	$321	$1,842
	CO2	7299.9	0.0	0.0	0.0	7299.9	$292	
	NOx	13.0	0.0	0.0	0.0	13.0	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	35.1	0.0	0.0	0.0	35.1	$26	
	TSP	4.1	0.0	0.0	0.0	4.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STLOGSH	Energy	18456.1	0.0	0.0	0.0	18456.1	$219	$1,257
	CO2	4983.2	0.0	0.0	0.0	4983.2	$199	
	NOx	8.9	0.0	0.0	0.0	8.9	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	24.0	0.0	0.0	0.0	24.0	$18	
	TSP	2.8	0.0	0.0	0.0	2.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STLOMOF	Energy	4964.4	0.0	75265.0	0.0	80229.4	$289	$1,660
	CO2	1340.4	0.0	5494.3	0.0	6834.7	$273	
	NOx	2.4	0.0	2.2	0.0	4.6	$1	
	CH4	0.0	0.0	0.4	0.0	0.4	$0	
	SOx	6.5	0.0	7.1	0.0	13.5	$10	
	TSP	0.7	0.0	0.6	0.0	1.3	$0	
	CO	0.0	0.0	1.0	0.0	1.0	$1	
	VOC	0.0	0.0	0.6	0.0	0.6	$3	
STLOMPF	Energy	4964.4	75265.0	0.0	0.0	80229.4	$231	$1,327
	CO2	1340.4	4244.9	0.0	0.0	5585.3	$223	
	NOx	2.4	4.8	0.0	0.0	7.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.7	0.1	0.0	0.0	0.9	$0	
	CO	0.0	0.4	0.0	0.0	0.4	$1	
	VOC	0.0	0.2	0.0	0.0	0.2	$1	
STLOMGF	Energy	4964.4	0.0	0.0	75265.0	80229.4	$215	$1,234
	CO2	1340.4	0.0	0.0	3838.5	5178.9	$207	
	NOx	2.4	0.0	0.0	2.1	4.5	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.7	0.0	0.0	0.5	1.2	$0	
	CO	0.0	0.0	0.0	0.5	0.5	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
STLOHGF	Energy	4964.4	0.0	0.0	65229.7	70194.1	$194	$1,114
	CO2	1340.4	0.0	0.0	3326.7	4667.1	$187	
	NOx	2.4	0.0	0.0	1.8	4.2	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.7	0.0	0.0	0.4	1.1	$0	
	CO	0.0	0.0	0.0	0.5	0.5	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	

STSOEEH	Energy	29973.2	0.0	0.0	0.0	29973.2	$356	$2,042
	CO2	8092.8	0.0	0.0	0.0	8092.8	$324	
	NOx	14.4	0.0	0.0	0.0	14.4	$3	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	39.0	0.0	0.0	0.0	39.0	$29	
	TSP	4.5	0.0	0.0	0.0	4.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STSOASH	Energy	18700.6	0.0	0.0	0.0	18700.6	$222	$1,274
	CO2	5049.2	0.0	0.0	0.0	5049.2	$202	
	NOx	9.0	0.0	0.0	0.0	9.0	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	24.3	0.0	0.0	0.0	24.3	$18	
	TSP	2.8	0.0	0.0	0.0	2.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STSOGSH	Energy	13400.6	0.0	0.0	0.0	13400.6	$159	$913
	CO2	3618.2	0.0	0.0	0.0	3618.2	$145	
	NOx	6.4	0.0	0.0	0.0	6.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	17.4	0.0	0.0	0.0	17.4	$13	
	TSP	2.0	0.0	0.0	0.0	2.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
STSOMOF	Energy	4879.8	0.0	53810.0	0.0	58689.8	$222	$1,277
	CO2	1317.5	0.0	3928.1	0.0	5245.7	$210	
	NOx	2.3	0.0	1.6	0.0	3.9	$1	
	CH4	0.0	0.0	0.3	0.0	0.3	$0	
	SOx	6.3	0.0	5.1	0.0	11.4	$8	
	TSP	0.7	0.0	0.4	0.0	1.2	$0	
	CO	0.0	0.0	0.7	0.0	0.7	$1	
	VOC	0.0	0.0	0.4	0.0	0.4	$2	
STSOMPF	Energy	4879.8	53810.0	0.0	0.0	58689.8	$181	$1,040
	CO2	1317.5	3034.9	0.0	0.0	4352.4	$174	
	NOx	2.3	3.4	0.0	0.0	5.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.3	0.0	0.0	0.0	6.3	$5	
	TSP	0.7	0.1	0.0	0.0	0.8	$0	
	CO	0.0	0.3	0.0	0.0	0.3	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
STSOMGF	Energy	4879.8	0.0	0.0	53810.0	58689.8	$169	$973
	CO2	1317.5	0.0	0.0	2744.3	4061.9	$162	
	NOx	2.3	0.0	0.0	1.5	3.8	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.3	0.0	0.0	0.0	6.4	$5	
	TSP	0.7	0.0	0.0	0.3	1.1	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
STSOHGF	Energy	4879.8	0.0	0.0	46635.3	51515.1	$154	$887
	CO2	1317.5	0.0	0.0	2378.4	3695.9	$148	
	NOx	2.3	0.0	0.0	1.3	3.6	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.3	0.0	0.0	0.0	6.4	$5	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.2	$1	

SBSOEEH	Energy	39967.6	0.0	0.0	0.0	39967.6	$474	$2,723
	CO2	10791.2	0.0	0.0	0.0	10791.2	$432	
	NOx	19.2	0.0	0.0	0.0	19.2	$4	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	52.0	0.0	0.0	0.0	52.0	$38	
	TSP	6.0	0.0	0.0	0.0	6.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$1	
SBSOASH	Energy	23919.8	0.0	0.0	0.0	23919.8	$284	$1,630
	CO2	6458.4	0.0	0.0	0.0	6458.4	$258	
	NOx	11.5	0.0	0.0	0.0	11.5	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	31.1	0.0	0.0	0.0	31.1	$23	
	TSP	3.6	0.0	0.0	0.0	3.6	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SBSOGSH	Energy	16957.8	0.0	0.0	0.0	16957.8	$201	$1,155
	CO2	4578.6	0.0	0.0	0.0	4578.6	$183	
	NOx	8.1	0.0	0.0	0.0	8.1	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	22.0	0.0	0.0	0.0	22.0	$16	
	TSP	2.5	0.0	0.0	0.0	2.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SBSOMOF	Energy	5004.0	0.0	63292.0	0.0	68296.0	$253	$1,452
	CO2	1351.1	0.0	4620.3	0.0	5971.4	$239	
	NOx	2.4	0.0	1.8	0.0	4.2	$1	
	CH4	0.0	0.0	0.3	0.0	0.3	$0	
	SOx	6.5	0.0	5.9	0.0	12.5	$9	
	TSP	0.8	0.0	0.5	0.0	1.3	$0	
	CO	0.0	0.0	0.8	0.0	0.8	$1	
	VOC	0.0	0.0	0.5	0.0	0.5	$3	
SBSOMPF	Energy	5004.0	63292.0	0.0	0.0	68296.0	$204	$1,173
	CO2	1351.1	3569.7	0.0	0.0	4920.7	$197	
	NOx	2.4	4.0	0.0	0.0	6.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.8	0.1	0.0	0.0	0.9	$0	
	CO	0.0	0.4	0.0	0.0	0.4	$0	
	VOC	0.0	0.1	0.0	0.0	0.2	$1	
SBSOMGF	Energy	5004.0	0.0	0.0	63292.0	68296.0	$190	$1,094
	CO2	1351.1	0.0	0.0	3227.9	4579.0	$183	
	NOx	2.4	0.0	0.0	1.8	4.2	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.8	0.0	0.0	0.4	1.1	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
SBSOHGF	Energy	5004.0	0.0	0.0	54853.1	59857.1	$173	$994
	CO2	1351.1	0.0	0.0	2797.5	4148.6	$166	
	NOx	2.4	0.0	0.0	1.5	3.9	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.5	0.0	0.0	0.0	6.5	$5	
	TSP	0.8	0.0	0.0	0.3	1.1	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	

SSDOEEH	Energy	28185.5	0.0	0.0	0.0	28185.5	$334	$1,920
	CO2	7610.1	0.0	0.0	0.0	7610.1	$304	
	NOx	13.5	0.0	0.0	0.0	13.5	$3	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	36.6	0.0	0.0	0.0	36.6	$27	
	TSP	4.2	0.0	0.0	0.0	4.2	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SSDOASH	Energy	17889.8	0.0	0.0	0.0	17889.8	$212	$1,219
	CO2	4830.3	0.0	0.0	0.0	4830.3	$193	
	NOx	8.6	0.0	0.0	0.0	8.6	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	23.3	0.0	0.0	0.0	23.3	$17	
	TSP	2.7	0.0	0.0	0.0	2.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SSDOGSH	Energy	12956.4	0.0	0.0	0.0	12956.4	$154	$883
	CO2	3498.2	0.0	0.0	0.0	3498.2	$140	
	NOx	6.2	0.0	0.0	0.0	6.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	16.8	0.0	0.0	0.0	16.8	$12	
	TSP	1.9	0.0	0.0	0.0	1.9	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SSDOMOF	Energy	4909.7	0.0	50647.0	0.0	55556.7	$213	$1,224
	CO2	1325.6	0.0	3697.2	0.0	5022.8	$201	
	NOx	2.4	0.0	1.5	0.0	3.8	$1	
	CH4	0.0	0.0	0.3	0.0	0.3	$0	
	SOx	6.4	0.0	4.8	0.0	11.1	$8	
	TSP	0.7	0.0	0.4	0.0	1.1	$0	
	CO	0.0	0.0	0.7	0.0	0.7	$1	
	VOC	0.0	0.0	0.4	0.0	0.4	$2	
SSDOMPF	Energy	4909.7	50647.0	0.0	0.0	55556.7	$174	$1,000
	CO2	1325.6	2856.5	0.0	0.0	4182.1	$167	
	NOx	2.4	3.2	0.0	0.0	5.6	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.4	0.0	0.0	0.0	6.4	$5	
	TSP	0.7	0.1	0.0	0.0	0.8	$0	
	CO	0.0	0.3	0.0	0.0	0.3	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
SSDOMGF	Energy	4909.7	0.0	0.0	50647.0	55556.7	$163	$937
	CO2	1325.6	0.0	0.0	2583.0	3908.6	$156	
	NOx	2.4	0.0	0.0	1.4	3.8	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.4	0.0	0.0	0.0	6.4	$5	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$0	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
SSDOHGF	Energy	4909.7	0.0	0.0	43894.1	48803.7	$149	$857
	CO2	1325.6	0.0	0.0	2238.6	3564.2	$143	
	NOx	2.4	0.0	0.0	1.2	3.6	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.4	0.0	0.0	0.0	6.4	$5	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

SREOEEH	Energy	18635.0	0.0	0.0	0.0	18635.0	$221	$1,270
	CO2	5031.5	0.0	0.0	0.0	5031.5	$201	
	NOx	8.9	0.0	0.0	0.0	8.9	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	24.2	0.0	0.0	0.0	24.2	$18	
	TSP	2.8	0.0	0.0	0.0	2.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SREOASH	Energy	12714.1	0.0	0.0	0.0	12714.1	$151	$866
	CO2	3432.8	0.0	0.0	0.0	3432.8	$137	
	NOx	6.1	0.0	0.0	0.0	6.1	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	16.5	0.0	0.0	0.0	16.5	$12	
	TSP	1.9	0.0	0.0	0.0	1.9	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SREOGSH	Energy	9464.4	0.0	0.0	0.0	9464.4	$112	$645
	CO2	2555.4	0.0	0.0	0.0	2555.4	$102	
	NOx	4.5	0.0	0.0	0.0	4.5	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	12.3	0.0	0.0	0.0	12.3	$9	
	TSP	1.4	0.0	0.0	0.0	1.4	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SREOMOF	Energy	4755.6	0.0	37780.0	0.0	42535.6	$172	$987
	CO2	1284.0	0.0	2757.9	0.0	4042.0	$162	
	NOx	2.3	0.0	1.1	0.0	3.4	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	6.2	0.0	3.6	0.0	9.7	$7	
	TSP	0.7	0.0	0.3	0.0	1.0	$0	
	CO	0.0	0.0	0.5	0.0	0.5	$1	
	VOC	0.0	0.0	0.3	0.0	0.3	$2	
SREOMPF	Energy	4755.6	37780.0	0.0	0.0	42535.6	$143	$820
	CO2	1284.0	2130.8	0.0	0.0	3414.8	$137	
	NOx	2.3	2.4	0.0	0.0	4.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.1	0.0	0.0	0.8	$0	
	CO	0.0	0.2	0.0	0.0	0.2	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
SREOMGF	Energy	4755.6	0.0	0.0	37780.0	42535.6	$135	$774
	CO2	1284.0	0.0	0.0	1926.8	3210.8	$128	
	NOx	2.3	0.0	0.0	1.1	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
SREOHGF	Energy	4755.6	0.0	0.0	32742.7	37498.3	$124	$714
	CO2	1284.0	0.0	0.0	1669.9	2953.9	$118	
	NOx	2.3	0.0	0.0	0.9	3.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

SRIOEEH	Energy	11968.2	0.0	0.0	0.0	11968.2	$142	$815
	CO2	3231.4	0.0	0.0	0.0	3231.4	$129	
	NOx	5.7	0.0	0.0	0.0	5.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	15.6	0.0	0.0	0.0	15.6	$11	
	TSP	1.8	0.0	0.0	0.0	1.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRIOASH	Energy	9104.0	0.0	0.0	0.0	9104.0	$108	$620
	CO2	2458.1	0.0	0.0	0.0	2458.1	$98	
	NOx	4.4	0.0	0.0	0.0	4.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	11.8	0.0	0.0	0.0	11.8	$9	
	TSP	1.4	0.0	0.0	0.0	1.4	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRIOGSH	Energy	7086.6	0.0	0.0	0.0	7086.6	$84	$483
	CO2	1913.4	0.0	0.0	0.0	1913.4	$77	
	NOx	3.4	0.0	0.0	0.0	3.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	9.2	0.0	0.0	0.0	9.2	$7	
	TSP	1.1	0.0	0.0	0.0	1.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRIOMOF	Energy	4555.4	0.0	24888.0	0.0	29443.4	$130	$747
	CO2	1230.0	0.0	1816.8	0.0	3046.8	$122	
	NOx	2.2	0.0	0.7	0.0	2.9	$1	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.9	0.0	2.3	0.0	8.3	$6	
	TSP	0.7	0.0	0.2	0.0	0.9	$0	
	CO	0.0	0.0	0.3	0.0	0.3	$0	
	VOC	0.0	0.0	0.2	0.0	0.2	$1	
SRIOMPF	Energy	4555.4	24888.0	0.0	0.0	29443.4	$111	$637
	CO2	1230.0	1403.7	0.0	0.0	2633.7	$105	
	NOx	2.2	1.6	0.0	0.0	3.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.0	0.0	0.0	0.7	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
SRIOMGF	Energy	4555.4	0.0	0.0	24888.0	29443.4	$106	$606
	CO2	1230.0	0.0	0.0	1269.3	2499.3	$100	
	NOx	2.2	0.0	0.0	0.7	2.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.0	0.0	0.1	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	
SRIOHGF	Energy	4555.4	0.0	0.0	21569.6	26125.0	$99	$567
	CO2	1230.0	0.0	0.0	1100.0	2330.0	$93	
	NOx	2.2	0.0	0.0	0.6	2.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.0	0.0	0.1	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	

ANNUAL ENERGY & EMISSIONS - NECH - ZONE A

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
TTLNEEH	Energy	29975.0	0.0	0.0	0.0	29975.0	$356	$2,042
	CO2	8093.3	0.0	0.0	0.0	8093.3	$324	
	NOx	14.4	0.0	0.0	0.0	14.4	$3	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	39.0	0.0	0.0	0.0	39.0	$29	
	TSP	4.5	0.0	0.0	0.0	4.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TTLNASH	Energy	21331.1	0.0	0.0	0.0	21331.1	$253	$1,453
	CO2	5759.4	0.0	0.0	0.0	5759.4	$230	
	NOx	10.2	0.0	0.0	0.0	10.2	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	27.7	0.0	0.0	0.0	27.7	$20	
	TSP	3.2	0.0	0.0	0.0	3.2	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TTLNGSF	Energy	19681.9	0.0	0.0	0.0	19681.9	$233	$1,341
	CO2	5314.1	0.0	0.0	0.0	5314.1	$213	
	NOx	9.4	0.0	0.0	0.0	9.4	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	25.6	0.0	0.0	0.0	25.6	$19	
	TSP	3.0	0.0	0.0	0.0	3.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TTLNMOH	Energy	4376.2	0.0	44483.0	0.0	48859.2	$188	$1,079
	CO2	1181.6	0.0	3247.3	0.0	4428.8	$177	
	NOx	2.1	0.0	1.3	0.0	3.4	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	5.7	0.0	4.2	0.0	9.9	$7	
	TSP	0.7	0.0	0.4	0.0	1.0	$0	
	CO	0.0	0.0	0.6	0.0	0.6	$1	
	VOC	0.0	0.0	0.4	0.0	0.4	$2	
TTLNMPH	Energy	4376.2	44483.0	0.0	0.0	48859.2	$154	$883
	CO2	1181.6	2508.8	0.0	0.0	3690.4	$148	
	NOx	2.1	2.8	0.0	0.0	4.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.7	0.0	0.0	0.0	5.7	$4	
	TSP	0.7	0.1	0.0	0.0	0.7	$0	
	CO	0.0	0.3	0.0	0.0	0.3	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
TTLNMGF	Energy	4617.0	0.0	0.0	60598.0	65215.0	$180	$1,036
	CO2	1246.6	0.0	0.0	3090.5	4337.1	$173	
	NOx	2.2	0.0	0.0	1.7	3.9	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.0	0.0	0.0	0.0	6.0	$4	
	TSP	0.7	0.0	0.0	0.4	1.1	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
TTLNHGF	Energy	4617.0	0.0	0.0	52518.3	57135.3	$164	$939
	CO2	1246.6	0.0	0.0	2678.4	3925.0	$157	
	NOx	2.2	0.0	0.0	1.5	3.7	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.0	0.0	0.0	0.0	6.0	$4	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	

TTSNEEH	Energy	19963.4	0.0	0.0	0.0	19963.4	$237	$1,360
	CO2	5390.1	0.0	0.0	0.0	5390.1	$216	
	NOx	9.6	0.0	0.0	0.0	9.6	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	26.0	0.0	0.0	0.0	26.0	$19	
	TSP	3.0	0.0	0.0	0.0	3.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TTSNASH	Energy	15272.3	0.0	0.0	0.0	15272.3	$181	$1,041
	CO2	4123.5	0.0	0.0	0.0	4123.5	$165	
	NOx	7.3	0.0	0.0	0.0	7.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	19.9	0.0	0.0	0.0	19.9	$15	
	TSP	2.3	0.0	0.0	0.0	2.3	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTSNGSF	Energy	15975.7	0.0	0.0	0.0	15975.7	$190	$1,088
	CO2	4313.4	0.0	0.0	0.0	4313.4	$173	
	NOx	7.7	0.0	0.0	0.0	7.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	20.8	0.0	0.0	0.0	20.8	$15	
	TSP	2.4	0.0	0.0	0.0	2.4	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTSNMOH	Energy	4236.1	0.0	28946.0	0.0	33182.1	$139	$797
	CO2	1143.8	0.0	2113.1	0.0	3256.8	$130	
	NOx	2.0	0.0	0.8	0.0	2.9	$1	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.5	0.0	2.7	0.0	8.2	$6	
	TSP	0.6	0.0	0.2	0.0	0.9	$0	
	CO	0.0	0.0	0.4	0.0	0.4	$1	
	VOC	0.0	0.0	0.2	0.0	0.2	$1	
TTSNMPH	Energy	4236.1	28946.0	0.0	0.0	33182.1	$116	$669
	CO2	1143.8	1632.6	0.0	0.0	2776.3	$111	
	NOx	2.0	1.8	0.0	0.0	3.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.1	0.0	0.0	0.7	$0	
	CO	0.0	0.2	0.0	0.0	0.2	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
TTSNMGF	Energy	4557.6	0.0	0.0	43278.0	47835.6	$144	$825
	CO2	1230.6	0.0	0.0	2207.2	3437.7	$138	
	NOx	2.2	0.0	0.0	1.2	3.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.0	0.0	0.3	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
TTSNHGF	Energy	4557.6	0.0	0.0	37507.6	42065.2	$132	$757
	CO2	1230.6	0.0	0.0	1912.9	3143.4	$126	
	NOx	2.2	0.0	0.0	1.1	3.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

TBSNEEH	Energy	25262.6	0.0	0.0	0.0	25262.6	$300	$1,721
	CO2	6820.9	0.0	0.0	0.0	6820.9	$273	
	NOx	12.1	0.0	0.0	0.0	12.1	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	32.8	0.0	0.0	0.0	32.8	$24	
	TSP	3.8	0.0	0.0	0.0	3.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TBSNASH	Energy	17574.1	0.0	0.0	0.0	17574.1	$208	$1,197
	CO2	4745.0	0.0	0.0	0.0	4745.0	$190	
	NOx	8.4	0.0	0.0	0.0	8.4	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	22.8	0.0	0.0	0.0	22.8	$17	
	TSP	2.6	0.0	0.0	0.0	2.6	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TBSNGSF	Energy	18216.4	0.0	0.0	0.0	18216.4	$216	$1,241
	CO2	4918.4	0.0	0.0	0.0	4918.4	$197	
	NOx	8.7	0.0	0.0	0.0	8.7	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	23.7	0.0	0.0	0.0	23.7	$17	
	TSP	2.7	0.0	0.0	0.0	2.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TBSNMOH	Energy	4347.7	0.0	35058.0	0.0	39405.7	$159	$912
	CO2	1173.9	0.0	2559.2	0.0	3733.1	$149	
	NOx	2.1	0.0	1.0	0.0	3.1	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	5.7	0.0	3.3	0.0	8.9	$7	
	TSP	0.7	0.0	0.3	0.0	0.9	$0	
	CO	0.0	0.0	0.5	0.0	0.5	$1	
	VOC	0.0	0.0	0.3	0.0	0.3	$2	
TBSNMPH	Energy	4347.7	35058.0	0.0	0.0	39405.7	$132	$757
	CO2	1173.9	1977.3	0.0	0.0	3151.2	$126	
	NOx	2.1	2.2	0.0	0.0	4.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.7	0.0	0.0	0.0	5.7	$4	
	TSP	0.7	0.1	0.0	0.0	0.7	$0	
	CO	0.0	0.2	0.0	0.0	0.2	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
TBSNMGF	Energy	4685.8	0.0	0.0	51449.0	56134.8	$162	$931
	CO2	1265.2	0.0	0.0	2623.9	3889.1	$156	
	NOx	2.2	0.0	0.0	1.4	3.7	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.1	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
TBSNHGF	Energy	4685.8	0.0	0.0	44589.1	49274.9	$148	$850
	CO2	1265.2	0.0	0.0	2274.0	3539.2	$142	
	NOx	2.2	0.0	0.0	1.2	3.5	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.1	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

TSDNEEH	Energy	18905.8	0.0	0.0	0.0	18905.8	$224	$1,288
	CO2	5104.6	0.0	0.0	0.0	5104.6	$204	
	NOx	9.1	0.0	0.0	0.0	9.1	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	24.6	0.0	0.0	0.0	24.6	$18	
	TSP	2.8	0.0	0.0	0.0	2.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
TSDNASH	Energy	14183.6	0.0	0.0	0.0	14183.6	$168	$966
	CO2	3829.6	0.0	0.0	0.0	3829.6	$153	
	NOx	6.8	0.0	0.0	0.0	6.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	18.4	0.0	0.0	0.0	18.4	$14	
	TSP	2.1	0.0	0.0	0.0	2.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TSDNGSF	Energy	15277.3	0.0	0.0	0.0	15277.3	$181	$1,041
	CO2	4124.9	0.0	0.0	0.0	4124.9	$165	
	NOx	7.3	0.0	0.0	0.0	7.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	19.9	0.0	0.0	0.0	19.9	$15	
	TSP	2.3	0.0	0.0	0.0	2.3	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TSDNMOH	Energy	4234.0	0.0	26037.0	0.0	30271.0	$130	$746
	CO2	1143.2	0.0	1900.7	0.0	3043.9	$122	
	NOx	2.0	0.0	0.8	0.0	2.8	$1	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.5	0.0	2.4	0.0	8.0	$6	
	TSP	0.6	0.0	0.2	0.0	0.8	$0	
	CO	0.0	0.0	0.3	0.0	0.3	$0	
	VOC	0.0	0.0	0.2	0.0	0.2	$1	
TSDNMPH	Energy	4234.0	26037.0	0.0	0.0	30271.0	$110	$631
	CO2	1143.2	1468.5	0.0	0.0	2611.7	$104	
	NOx	2.0	1.7	0.0	0.0	3.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.0	0.0	0.0	0.7	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
TSDNMGF	Energy	4590.7	0.0	0.0	40558.0	45148.7	$138	$795
	CO2	1239.5	0.0	0.0	2068.5	3308.0	$132	
	NOx	2.2	0.0	0.0	1.1	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.0	0.0	0.0	0.0	6.0	$4	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
TSDNHGF	Energy	4590.7	0.0	0.0	35150.3	39741.0	$127	$731
	CO2	1239.5	0.0	0.0	1792.7	3032.2	$121	
	NOx	2.2	0.0	0.0	1.0	3.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.0	0.0	0.0	0.0	6.0	$4	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

TRENEEH	Energy	12316.3	0.0	0.0	0.0	12316.3	$146	$839
	CO2	3325.4	0.0	0.0	0.0	3325.4	$133	
	NOx	5.9	0.0	0.0	0.0	5.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	16.0	0.0	0.0	0.0	16.0	$12	
	TSP	1.8	0.0	0.0	0.0	1.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRENASH	Energy	10310.4	0.0	0.0	0.0	10310.4	$122	$702
	CO2	2783.8	0.0	0.0	0.0	2783.8	$111	
	NOx	4.9	0.0	0.0	0.0	4.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	13.4	0.0	0.0	0.0	13.4	$10	
	TSP	1.5	0.0	0.0	0.0	1.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRENGSF	Energy	12582.0	0.0	0.0	0.0	12582.0	$149	$857
	CO2	3397.1	0.0	0.0	0.0	3397.1	$136	
	NOx	6.0	0.0	0.0	0.0	6.0	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	16.4	0.0	0.0	0.0	16.4	$12	
	TSP	1.9	0.0	0.0	0.0	1.9	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRENMOH	Energy	4041.4	0.0	15944.0	0.0	19985.4	$97	$555
	CO2	1091.2	0.0	1163.9	0.0	2255.1	$90	
	NOx	1.9	0.0	0.5	0.0	2.4	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.3	0.0	1.5	0.0	6.8	$5	
	TSP	0.6	0.0	0.1	0.0	0.7	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TRENMPH	Energy	4041.4	15944.0	0.0	0.0	19985.4	$84	$485
	CO2	1091.2	899.2	0.0	0.0	1990.4	$80	
	NOx	1.9	1.0	0.0	0.0	3.0	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.3	0.0	0.0	0.0	5.3	$4	
	TSP	0.6	0.0	0.0	0.0	0.6	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRENMGF	Energy	4444.2	0.0	0.0	30518.0	34962.2	$116	$666
	CO2	1199.9	0.0	0.0	1556.4	2756.4	$110	
	NOx	2.1	0.0	0.0	0.9	3.0	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.8	0.0	0.0	0.0	5.8	$4	
	TSP	0.7	0.0	0.0	0.2	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
TRENHGF	Energy	4444.2	0.0	0.0	26448.9	30893.1	$108	$617
	CO2	1199.9	0.0	0.0	1348.9	2548.8	$102	
	NOx	2.1	0.0	0.0	0.7	2.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.8	0.0	0.0	0.0	5.8	$4	
	TSP	0.7	0.0	0.0	0.2	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	

TRINEEH	Energy	7581.2	0.0	0.0	0.0	7581.2	$90	$517
	CO2	2046.9	0.0	0.0	0.0	2046.9	$82	
	NOx	3.6	0.0	0.0	0.0	3.6	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	9.9	0.0	0.0	0.0	9.9	$7	
	TSP	1.1	0.0	0.0	0.0	1.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRINASH	Energy	6984.0	0.0	0.0	0.0	6984.0	$83	$476
	CO2	1885.7	0.0	0.0	0.0	1885.7	$75	
	NOx	3.4	0.0	0.0	0.0	3.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	9.1	0.0	0.0	0.0	9.1	$7	
	TSP	1.0	0.0	0.0	0.0	1.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRINGSF	Energy	9407.5	0.0	0.0	0.0	9407.5	$112	$641
	CO2	2540.0	0.0	0.0	0.0	2540.0	$102	
	NOx	4.5	0.0	0.0	0.0	4.5	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	12.2	0.0	0.0	0.0	12.2	$9	
	TSP	1.4	0.0	0.0	0.0	1.4	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRINMOH	Energy	3847.3	0.0	8053.0	0.0	11900.3	$70	$404
	CO2	1038.8	0.0	587.9	0.0	1626.6	$65	
	NOx	1.8	0.0	0.2	0.0	2.1	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.0	0.0	0.8	0.0	5.8	$4	
	TSP	0.6	0.0	0.1	0.0	0.6	$0	
	CO	0.0	0.0	0.1	0.0	0.1	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$0	
TRINMPH	Energy	3847.3	8053.0	0.0	0.0	11900.3	$64	$368
	CO2	1038.8	454.2	0.0	0.0	1493.0	$60	
	NOx	1.8	0.5	0.0	0.0	2.4	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.0	0.0	0.0	0.0	5.0	$4	
	TSP	0.6	0.0	0.0	0.0	0.6	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRINMGF	Energy	4232.9	0.0	0.0	19102.0	23334.9	$90	$516
	CO2	1142.9	0.0	0.0	974.2	2117.1	$85	
	NOx	2.0	0.0	0.0	0.5	2.6	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.0	0.0	0.1	0.7	$0	
	CO	0.0	0.0	0.0	0.1	0.1	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	
TRINHGF	Energy	4232.9	0.0	0.0	16555.1	20787.9	$85	$485
	CO2	1142.9	0.0	0.0	844.3	1987.2	$79	
	NOx	2.0	0.0	0.0	0.5	2.5	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.0	0.0	0.1	0.7	$0	
	CO	0.0	0.0	0.0	0.1	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.1	$0	

ANNUAL ENERGY & EMISSIONS - NECH - ZONE B

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
STLNEEH	Energy	40952.9	0.0	0.0	0.0	40952.9	$486	$2,790
	CO2	11057.3	0.0	0.0	0.0	11057.3	$442	
	NOx	19.7	0.0	0.0	0.0	19.7	$4	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	53.2	0.0	0.0	0.0	53.2	$39	
	TSP	6.1	0.0	0.0	0.0	6.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$1	
STLNASH	Energy	26786.2	0.0	0.0	0.0	26786.2	$318	$1,825
	CO2	7232.3	0.0	0.0	0.0	7232.3	$289	
	NOx	12.9	0.0	0.0	0.0	12.9	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	34.8	0.0	0.0	0.0	34.8	$26	
	TSP	4.0	0.0	0.0	0.0	4.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STLNGSH	Energy	21781.0	0.0	0.0	0.0	21781.0	$258	$1,484
	CO2	5880.9	0.0	0.0	0.0	5880.9	$235	
	NOx	10.5	0.0	0.0	0.0	10.5	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	28.3	0.0	0.0	0.0	28.3	$21	
	TSP	3.3	0.0	0.0	0.0	3.3	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STLNMOH	Energy	4664.2	0.0	53951.0	0.0	58615.2	$220	$1,265
	CO2	1259.3	0.0	3938.4	0.0	5197.7	$208	
	NOx	2.2	0.0	1.6	0.0	3.8	$1	
	CH4	0.0	0.0	0.3	0.0	0.3	$0	
	SOx	6.1	0.0	5.1	0.0	11.1	$8	
	TSP	0.7	0.0	0.4	0.0	1.1	$0	
	CO	0.0	0.0	0.7	0.0	0.7	$1	
	VOC	0.0	0.0	0.4	0.0	0.4	$2	
STLNMPH	Energy	4664.2	53951.0	0.0	0.0	58615.2	$179	$1,027
	CO2	1259.3	3042.8	0.0	0.0	4302.2	$172	
	NOx	2.2	3.4	0.0	0.0	5.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.1	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.1	0.0	0.0	0.8	$0	
	CO	0.0	0.3	0.0	0.0	0.3	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
STLNMGH	Energy	4782.0	0.0	0.0	64428.0	69210.0	$190	$1,092
	CO2	1291.1	0.0	0.0	3285.8	4577.0	$183	
	NOx	2.3	0.0	0.0	1.8	4.1	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.4	1.1	$0	
	CO	0.0	0.0	0.0	0.5	0.5	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
STLNHGH	Energy	4782.0	0.0	0.0	65838.0	70620.0	$193	$1,109
	CO2	1291.1	0.0	0.0	3357.7	4648.9	$186	
	NOx	2.3	0.0	0.0	1.8	4.1	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.4	1.1	$0	
	CO	0.0	0.0	0.0	0.5	0.5	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	

STSNEEH	Energy	27557.6	0.0	0.0	0.0	27557.6	$327	$1,878
	CO2	7440.6	0.0	0.0	0.0	7440.6	$298	
	NOx	13.2	0.0	0.0	0.0	13.2	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	35.8	0.0	0.0	0.0	35.8	$26	
	TSP	4.1	0.0	0.0	0.0	4.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STSNASH	Energy	18609.5	0.0	0.0	0.0	18609.5	$221	$1,268
	CO2	5024.6	0.0	0.0	0.0	5024.6	$201	
	NOx	8.9	0.0	0.0	0.0	8.9	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	24.2	0.0	0.0	0.0	24.2	$18	
	TSP	2.8	0.0	0.0	0.0	2.8	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
STSNGSH	Energy	16202.0	0.0	0.0	0.0	16202.0	$192	$1,104
	CO2	4374.5	0.0	0.0	0.0	4374.5	$175	
	NOx	7.8	0.0	0.0	0.0	7.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	21.1	0.0	0.0	0.0	21.1	$15	
	TSP	2.4	0.0	0.0	0.0	2.4	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
STSNMOH	Energy	4519.4	0.0	34421.0	0.0	38940.4	$159	$912
	CO2	1220.2	0.0	2512.7	0.0	3733.0	$149	
	NOx	2.2	0.0	1.0	0.0	3.2	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	5.9	0.0	3.2	0.0	9.1	$7	
	TSP	0.7	0.0	0.3	0.0	1.0	$0	
	CO	0.0	0.0	0.4	0.0	0.4	$1	
	VOC	0.0	0.0	0.3	0.0	0.3	$2	
STSNMPH	Energy	4519.4	34421.0	0.0	0.0	38940.4	$132	$760
	CO2	1220.2	1941.3	0.0	0.0	3161.6	$126	
	NOx	2.2	2.2	0.0	0.0	4.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.1	0.0	0.0	0.7	$0	
	CO	0.0	0.2	0.0	0.0	0.2	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
STSNMGH	Energy	4649.0	0.0	0.0	42884.0	47533.0	$144	$827
	CO2	1255.2	0.0	0.0	2187.1	3442.3	$138	
	NOx	2.2	0.0	0.0	1.2	3.4	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.0	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
STSNHGH	Energy	4649.0	0.0	0.0	37149.0	41798.0	$132	$759
	CO2	1255.2	0.0	0.0	1894.6	3149.8	$126	
	NOx	2.2	0.0	0.0	1.0	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.0	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

SBSNEEH	Energy	36428.8	0.0	0.0	0.0	36428.8	$432	$2,482
	CO2	9835.8	0.0	0.0	0.0	9835.8	$393	
	NOx	17.5	0.0	0.0	0.0	17.5	$3	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	47.4	0.0	0.0	0.0	47.4	$35	
	TSP	5.5	0.0	0.0	0.0	5.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$1	
SBSNASH	Energy	23335.2	0.0	0.0	0.0	23335.2	$277	$1,590
	CO2	6300.5	0.0	0.0	0.0	6300.5	$252	
	NOx	11.2	0.0	0.0	0.0	11.2	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	30.3	0.0	0.0	0.0	30.3	$22	
	TSP	3.5	0.0	0.0	0.0	3.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SBSNGSH	Energy	17990.0	0.0	0.0	0.0	17990.0	$213	$1,226
	CO2	4857.3	0.0	0.0	0.0	4857.3	$194	
	NOx	8.6	0.0	0.0	0.0	8.6	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	23.4	0.0	0.0	0.0	23.4	$17	
	TSP	2.7	0.0	0.0	0.0	2.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SBSNMOH	Energy	4693.3	0.0	46470.0	0.0	51163.3	$198	$1,136
	CO2	1267.2	0.0	3392.3	0.0	4659.5	$186	
	NOx	2.3	0.0	1.3	0.0	3.6	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	6.1	0.0	4.4	0.0	10.5	$8	
	TSP	0.7	0.0	0.4	0.0	1.1	$0	
	CO	0.0	0.0	0.6	0.0	0.6	$1	
	VOC	0.0	0.0	0.4	0.0	0.4	$2	
SBSNMPH	Energy	4693.3	46470.0	0.0	0.0	51163.3	$162	$930
	CO2	1267.2	2620.9	0.0	0.0	3888.1	$156	
	NOx	2.3	3.0	0.0	0.0	5.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.1	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.1	0.0	0.0	0.8	$0	
	CO	0.0	0.3	0.0	0.0	0.3	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$1	
SBSNMGH	Energy	4748.0	0.0	0.0	56898.0	61646.0	$174	$1,000
	CO2	1282.0	0.0	0.0	2901.8	4183.8	$167	
	NOx	2.3	0.0	0.0	1.6	3.9	$1	
	CH4	0.0	0.0	0.0	0.1	0.1	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.3	1.1	$0	
	CO	0.0	0.0	0.0	0.4	0.4	$1	
	VOC	0.0	0.0	0.0	0.2	0.2	$1	
SBSNHGH	Energy	4748.0	0.0	0.0	49311.6	54059.6	$158	$910
	CO2	1282.0	0.0	0.0	2514.9	3796.9	$152	
	NOx	2.3	0.0	0.0	1.4	3.7	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.2	0.0	0.0	0.0	6.2	$5	
	TSP	0.7	0.0	0.0	0.3	1.0	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.2	$1	

SSDNEEH	Energy	25978.7	0.0	0.0	0.0	25978.7	$308	$1,770
	CO2	7014.2	0.0	0.0	0.0	7014.2	$281	
	NOx	12.5	0.0	0.0	0.0	12.5	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	33.8	0.0	0.0	0.0	33.8	$25	
	TSP	3.9	0.0	0.0	0.0	3.9	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SSDNASH	Energy	17684.6	0.0	0.0	0.0	17684.6	$210	$1,205
	CO2	4774.9	0.0	0.0	0.0	4774.9	$191	
	NOx	8.5	0.0	0.0	0.0	8.5	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	23.0	0.0	0.0	0.0	23.0	$17	
	TSP	2.7	0.0	0.0	0.0	2.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SSDNGSH	Energy	15153.0	0.0	0.0	0.0	15153.0	$180	$1,032
	CO2	4091.3	0.0	0.0	0.0	4091.3	$164	
	NOx	7.3	0.0	0.0	0.0	7.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	19.7	0.0	0.0	0.0	19.7	$14	
	TSP	2.3	0.0	0.0	0.0	2.3	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SSDNMOH	Energy	4527.7	0.0	32326.0	0.0	36853.7	$153	$876
	CO2	1222.5	0.0	2359.8	0.0	3582.3	$143	
	NOx	2.2	0.0	0.9	0.0	3.1	$1	
	CH4	0.0	0.0	0.2	0.0	0.2	$0	
	SOx	5.9	0.0	3.0	0.0	8.9	$7	
	TSP	0.7	0.0	0.3	0.0	0.9	$0	
	CO	0.0	0.0	0.4	0.0	0.4	$1	
	VOC	0.0	0.0	0.3	0.0	0.3	$1	
SSDNMPH	Energy	4527.7	32326.0	0.0	0.0	36853.7	$128	$733
	CO2	1222.5	1823.2	0.0	0.0	3045.7	$122	
	NOx	2.2	2.1	0.0	0.0	4.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.9	0.0	0.0	0.0	5.9	$4	
	TSP	0.7	0.1	0.0	0.0	0.7	$0	
	CO	0.0	0.2	0.0	0.0	0.2	$0	
	VOC	0.0	0.1	0.0	0.0	0.1	$0	
SSDNMGH	Energy	4644.0	0.0	0.0	38869.0	43513.0	$136	$779
	CO2	1253.9	0.0	0.0	1982.3	3236.2	$129	
	NOx	2.2	0.0	0.0	1.1	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.0	0.0	0.0	0.0	6.1	$4	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.3	0.3	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	
SSDNHGH	Energy	4844.0	0.0	0.0	33686.0	38530.0	$127	$731
	CO2	1307.9	0.0	0.0	1718.0	3025.9	$121	
	NOx	2.3	0.0	0.0	0.9	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	6.3	0.0	0.0	0.0	6.3	$5	
	TSP	0.7	0.0	0.0	0.2	0.9	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$1	

SRENEEH	Energy	17082.0	0.0	0.0	0.0	17082.0	$203	$1,164
	CO2	4612.1	0.0	0.0	0.0	4612.1	$184	
	NOx	8.2	0.0	0.0	0.0	8.2	$2	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	22.2	0.0	0.0	0.0	22.2	$16	
	TSP	2.6	0.0	0.0	0.0	2.6	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.1	0.0	0.0	0.0	0.1	$0	
SRENASH	Energy	12604.7	0.0	0.0	0.0	12604.7	$150	$859
	CO2	3403.3	0.0	0.0	0.0	3403.3	$136	
	NOx	6.1	0.0	0.0	0.0	6.1	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	16.4	0.0	0.0	0.0	16.4	$12	
	TSP	1.9	0.0	0.0	0.0	1.9	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRENGSH	Energy	11655.0	0.0	0.0	0.0	11655.0	$138	$794
	CO2	3146.9	0.0	0.0	0.0	3146.9	$126	
	NOx	5.6	0.0	0.0	0.0	5.6	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	15.2	0.0	0.0	0.0	15.2	$11	
	TSP	1.7	0.0	0.0	0.0	1.7	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRENMOH	Energy	4331.2	0.0	19782.0	0.0	24113.2	$112	$642
	CO2	1169.4	0.0	1444.1	0.0	2613.5	$105	
	NOx	2.1	0.0	0.6	0.0	2.7	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.6	0.0	1.9	0.0	7.5	$5	
	TSP	0.6	0.0	0.2	0.0	0.8	$0	
	CO	0.0	0.0	0.3	0.0	0.3	$0	
	VOC	0.0	0.0	0.2	0.0	0.2	$1	
SRENMPH	Energy	4331.2	19782.0	0.0	0.0	24113.2	$97	$555
	CO2	1169.4	1115.7	0.0	0.0	2285.1	$91	
	NOx	2.1	1.3	0.0	0.0	3.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.6	0.0	0.0	0.0	5.6	$4	
	TSP	0.6	0.0	0.0	0.0	0.7	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.1	$0	
SRENMGH	Energy	4468.0	0.0	0.0	26452.0	30920.0	$108	$619
	CO2	1206.4	0.0	0.0	1349.1	2555.4	$102	
	NOx	2.1	0.0	0.0	0.7	2.9	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.8	0.0	0.0	0.0	5.8	$4	
	TSP	0.7	0.0	0.0	0.2	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	
SRENHGH	Energy	4468.0	0.0	0.0	22925.0	27393.0	$100	$577
	CO2	1206.4	0.0	0.0	1169.2	2375.5	$95	
	NOx	2.1	0.0	0.0	0.6	2.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.8	0.0	0.0	0.0	5.8	$4	
	TSP	0.7	0.0	0.0	0.1	0.8	$0	
	CO	0.0	0.0	0.0	0.2	0.2	$0	
	VOC	0.0	0.0	0.0	0.1	0.1	$0	

SRINEEH	Energy	10869.1	0.0	0.0	0.0	10869.1	$129	$741
	CO2	2934.7	0.0	0.0	0.0	2934.7	$117	
	NOx	5.2	0.0	0.0	0.0	5.2	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	14.1	0.0	0.0	0.0	14.1	$10	
	TSP	1.6	0.0	0.0	0.0	1.6	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRINASH	Energy	8903.9	0.0	0.0	0.0	8903.9	$106	$607
	CO2	2404.0	0.0	0.0	0.0	2404.0	$96	
	NOx	4.3	0.0	0.0	0.0	4.3	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	11.6	0.0	0.0	0.0	11.6	$8	
	TSP	1.3	0.0	0.0	0.0	1.3	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRINGSH	Energy	9909.0	0.0	0.0	0.0	9909.0	$118	$675
	CO2	2675.4	0.0	0.0	0.0	2675.4	$107	
	NOx	4.8	0.0	0.0	0.0	4.8	$1	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	12.9	0.0	0.0	0.0	12.9	$9	
	TSP	1.5	0.0	0.0	0.0	1.5	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRINMOH	Energy	4155.8	0.0	10388.0	0.0	14543.8	$81	$466
	CO2	1122.1	0.0	758.3	0.0	1880.4	$75	
	NOx	2.0	0.0	0.3	0.0	2.3	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	5.4	0.0	1.0	0.0	6.4	$5	
	TSP	0.6	0.0	0.1	0.0	0.7	$0	
	CO	0.0	0.0	0.1	0.0	0.1	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
SRINMPH	Energy	4155.8	10388.0	0.0	0.0	14543.8	$73	$420
	CO2	1122.1	585.9	0.0	0.0	1708.0	$68	
	NOx	2.0	0.7	0.0	0.0	2.7	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.4	0.0	0.0	0.0	5.4	$4	
	TSP	0.6	0.0	0.0	0.0	0.6	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
SRINMGH	Energy	4248.0	0.0	0.0	14438.0	18686.0	$80	$461
	CO2	1147.0	0.0	0.0	736.3	1883.3	$75	
	NOx	2.0	0.0	0.0	0.4	2.4	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.0	0.0	0.1	0.7	$0	
	CO	0.0	0.0	0.0	0.1	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.1	$0	
SRINHGH	Energy	4248.0	0.0	0.0	12513.0	16761.0	$76	$438
	CO2	1147.0	0.0	0.0	638.2	1785.1	$71	
	NOx	2.0	0.0	0.0	0.4	2.4	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	5.5	0.0	0.0	0.0	5.5	$4	
	TSP	0.6	0.0	0.0	0.1	0.7	$0	
	CO	0.0	0.0	0.0	0.1	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.1	$0	

ANNUAL ENERGY & EMISSION SAVINGS - ZONE 1/A

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
TTLOEEH	Energy	1253.9	0.0	0.0	0.0	1253.9	$15	$85
	CO2	338.5	0.0	0.0	0.0	338.5	$14	
	NOx	0.6	0.0	0.0	0.0	0.6	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	1.6	0.0	0.0	0.0	1.6	$1	
	TSP	0.2	0.0	0.0	0.0	0.2	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTLOASH	Energy	-3041.3	0.0	0.0	0.0	-3041.3	($36)	($207)
	CO2	-821.1	0.0	0.0	0.0	-821.1	($33)	
	NOx	-1.5	0.0	0.0	0.0	-1.5	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-4.0	0.0	0.0	0.0	-4.0	($3)	
	TSP	-0.5	0.0	0.0	0.0	-0.5	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TTLOGSH	Energy	-6009.5	0.0	0.0	0.0	-6009.5	($71)	($409)
	CO2	-1622.6	0.0	0.0	0.0	-1622.6	($65)	
	NOx	-2.9	0.0	0.0	0.0	-2.9	($1)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-7.8	0.0	0.0	0.0	-7.8	($6)	
	TSP	-0.9	0.0	0.0	0.0	-0.9	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TTLOMOF	Energy	266.8	0.0	16044.0	0.0	16310.8	$52	$300
	CO2	72.0	0.0	1171.2	0.0	1243.2	$50	
	NOx	0.1	0.0	0.5	0.0	0.6	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.3	0.0	1.5	0.0	1.9	$1	
	TSP	0.0	0.0	0.1	0.0	0.2	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TTLOMPF	Energy	266.8	16044.0	0.0	0.0	16310.8	$40	$229
	CO2	72.0	904.9	0.0	0.0	976.9	$39	
	NOx	0.1	1.0	0.0	0.0	1.2	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.3	0.0	0.0	0.0	0.3	$0	
	TSP	0.0	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTLOMGF	Energy	25.9	0.0	0.0	-71.0	-45.1	$0	$1
	CO2	7.0	0.0	0.0	-3.6	3.4	$0	
	NOx	0.0	0.0	0.0	-0.0	0.0	$0	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	0.0	0.0	0.0	-0.0	0.0	$0	
	TSP	0.0	0.0	0.0	-0.0	0.0	$0	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	0.0	0.0	0.0	-0.0	-0.0	($0)	
TTLOHGF	Energy	25.9	0.0	0.0	-61.5	-35.6	$0	$1
	CO2	7.0	0.0	0.0	-3.1	3.9	$0	
	NOx	0.0	0.0	0.0	-0.0	0.0	$0	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	0.0	0.0	0.0	-0.0	0.0	$0	
	TSP	0.0	0.0	0.0	-0.0	0.0	$0	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	0.0	0.0	0.0	-0.0	-0.0	($0)	

TTSOEEH	Energy	820.8	0.0	0.0	0.0	820.8	$10	$56
	CO2	221.6	0.0	0.0	0.0	221.6	$9	
	NOx	0.4	0.0	0.0	0.0	0.4	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	1.1	0.0	0.0	0.0	1.1	$1	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTSOASH	Energy	-2236.7	0.0	0.0	0.0	-2236.7	($27)	($152)
	CO2	-603.9	0.0	0.0	0.0	-603.9	($24)	
	NOx	-1.1	0.0	0.0	0.0	-1.1	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-2.9	0.0	0.0	0.0	-2.9	($2)	
	TSP	-0.3	0.0	0.0	0.0	-0.3	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TTSOGSH	Energy	-5897.9	0.0	0.0	0.0	-5897.9	($70)	($402)
	CO2	-1592.4	0.0	0.0	0.0	-1592.4	($64)	
	NOx	-2.8	0.0	0.0	0.0	-2.8	($1)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-7.7	0.0	0.0	0.0	-7.7	($6)	
	TSP	-0.9	0.0	0.0	0.0	-0.9	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TTSOMOF	Energy	324.4	0.0	14575.0	0.0	14899.4	$48	$278
	CO2	87.6	0.0	1064.0	0.0	1151.6	$46	
	NOx	0.2	0.0	0.4	0.0	0.6	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.4	0.0	1.4	0.0	1.8	$1	
	TSP	0.0	0.0	0.1	0.0	0.2	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TTSOMPF	Energy	324.4	14575.0	0.0	0.0	14899.4	$37	$214
	CO2	87.6	822.0	0.0	0.0	909.6	$36	
	NOx	0.2	0.9	0.0	0.0	1.1	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.4	0.0	0.0	0.0	0.4	$0	
	TSP	0.0	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTSOMGF	Energy	2.9	0.0	0.0	243.0	245.9	$1	$3
	CO2	0.8	0.0	0.0	12.4	13.2	$1	
	NOx	0.0	0.0	0.0	0.0	0.0	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.0	0.0	0.0	0.0	0.0	$0	
	TSP	0.0	0.0	0.0	0.0	0.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TTSOHGF	Energy	2.9	0.0	0.0	210.6	213.5	$0	$3
	CO2	0.8	0.0	0.0	10.7	11.5	$0	
	NOx	0.0	0.0	0.0	0.0	0.0	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.0	0.0	0.0	0.0	0.0	$0	
	TSP	0.0	0.0	0.0	0.0	0.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	

TBSOEEH	Energy	1379.2	0.0	0.0	0.0	1379.2	$16	$94
	CO2	372.4	0.0	0.0	0.0	372.4	$15	
	NOx	0.7	0.0	0.0	0.0	0.7	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	1.8	0.0	0.0	0.0	1.8	$1	
	TSP	0.2	0.0	0.0	0.0	0.2	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TBSOASH	Energy	-1742.8	0.0	0.0	0.0	-1742.8	($21)	($119)
	CO2	-470.5	0.0	0.0	0.0	-470.5	($19)	
	NOx	-0.8	0.0	0.0	0.0	-0.8	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-2.3	0.0	0.0	0.0	-2.3	($2)	
	TSP	-0.3	0.0	0.0	0.0	-0.3	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TBSOGSH	Energy	-3912.5	0.0	0.0	0.0	-3912.5	($46)	($267)
	CO2	-1056.4	0.0	0.0	0.0	-1056.4	($42)	
	NOx	-1.9	0.0	0.0	0.0	-1.9	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-5.1	0.0	0.0	0.0	-5.1	($4)	
	TSP	-0.6	0.0	0.0	0.0	-0.6	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TBSOMOF	Energy	332.3	0.0	16194.0	0.0	16526.3	$53	$307
	CO2	89.7	0.0	1182.2	0.0	1271.9	$51	
	NOx	0.2	0.0	0.5	0.0	0.6	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.4	0.0	1.5	0.0	2.0	$1	
	TSP	0.0	0.0	0.1	0.0	0.2	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TBSOMPF	Energy	332.3	16194.0	0.0	0.0	16526.3	$41	$235
	CO2	89.7	913.3	0.0	0.0	1003.1	$40	
	NOx	0.2	1.0	0.0	0.0	1.2	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.4	0.0	0.0	0.0	0.4	$0	
	TSP	0.0	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TBSOMGF	Energy	-5.8	0.0	0.0	-197.0	-202.8	($0)	($3)
	CO2	-1.6	0.0	0.0	-10.0	-11.6	($0)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	
TBSOHGF	Energy	-5.8	0.0	0.0	-170.7	-176.5	($0)	($2)
	CO2	-1.6	0.0	0.0	-8.7	-10.3	($0)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	

TSDOEEH	Energy	755.3	0.0	0.0	0.0	755.3	$9	$51
	CO2	203.9	0.0	0.0	0.0	203.9	$8	
	NOx	0.4	0.0	0.0	0.0	0.4	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	1.0	0.0	0.0	0.0	1.0	$1	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TSDOASH	Energy	-1701.0	0.0	0.0	0.0	-1701.0	($20)	($116)
	CO2	-459.3	0.0	0.0	0.0	-459.3	($18)	
	NOx	-0.8	0.0	0.0	0.0	-0.8	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-2.2	0.0	0.0	0.0	-2.2	($2)	
	TSP	-0.3	0.0	0.0	0.0	-0.3	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TSDOGSH	Energy	-5582.5	0.0	0.0	0.0	-5582.5	($66)	($380)
	CO2	-1507.3	0.0	0.0	0.0	-1507.3	($60)	
	NOx	-2.7	0.0	0.0	0.0	-2.7	($1)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-7.3	0.0	0.0	0.0	-7.3	($5)	
	TSP	-0.8	0.0	0.0	0.0	-0.8	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TSDOMOF	Energy	352.8	0.0	14341.0	0.0	14693.8	$48	$276
	CO2	95.3	0.0	1046.9	0.0	1142.1	$46	
	NOx	0.2	0.0	0.4	0.0	0.6	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.5	0.0	1.3	0.0	1.8	$1	
	TSP	0.1	0.0	0.1	0.0	0.2	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TSDOMPF	Energy	352.8	14341.0	0.0	0.0	14693.8	$37	$212
	CO2	95.3	808.8	0.0	0.0	904.1	$36	
	NOx	0.2	0.9	0.0	0.0	1.1	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.5	0.0	0.0	0.0	0.5	$0	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TSDOMGF	Energy	-4.0	0.0	0.0	-180.0	-184.0	($0)	($2)
	CO2	-1.1	0.0	0.0	-9.2	-10.2	($0)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	
TSDOHGF	Energy	-4.0	0.0	0.0	-156.0	-160.0	($0)	($2)
	CO2	-1.1	0.0	0.0	-8.0	-9.0	($0)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	

TREOEEH	Energy	534.6	0.0	0.0	0.0	534.6	$6	$36
	CO2	144.3	0.0	0.0	0.0	144.3	$6	
	NOx	0.3	0.0	0.0	0.0	0.3	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.7	0.0	0.0	0.0	0.7	$1	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TREOASH	Energy	-1260.7	0.0	0.0	0.0	-1260.7	($15)	($86)
	CO2	-340.4	0.0	0.0	0.0	-340.4	($14)	
	NOx	-0.6	0.0	0.0	0.0	-0.6	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-1.6	0.0	0.0	0.0	-1.6	($1)	
	TSP	-0.2	0.0	0.0	0.0	-0.2	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TREOGSH	Energy	-5329.8	0.0	0.0	0.0	-5329.8	($63)	($363)
	CO2	-1439.0	0.0	0.0	0.0	-1439.0	($58)	
	NOx	-2.6	0.0	0.0	0.0	-2.6	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-6.9	0.0	0.0	0.0	-6.9	($5)	
	TSP	-0.8	0.0	0.0	0.0	-0.8	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TREOMOF	Energy	396.4	0.0	14306.0	0.0	14702.4	$48	$278
	CO2	107.0	0.0	1044.3	0.0	1151.4	$46	
	NOx	0.2	0.0	0.4	0.0	0.6	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.5	0.0	1.3	0.0	1.9	$1	
	TSP	0.1	0.0	0.1	0.0	0.2	$0	
	CO	0.0	0.0	0.2	0.0	0.2	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$1	
TREOMPF	Energy	396.4	14306.0	0.0	0.0	14702.4	$37	$215
	CO2	107.0	806.9	0.0	0.0	913.9	$37	
	NOx	0.2	0.9	0.0	0.0	1.1	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.5	0.0	0.0	0.0	0.5	$0	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TREOMGF	Energy	-6.5	0.0	0.0	-268.0	-274.5	($1)	($4)
	CO2	-1.7	0.0	0.0	-13.7	-15.4	($1)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	
TREOHGF	Energy	-6.5	0.0	0.0	-232.3	-238.7	($1)	($3)
	CO2	-1.7	0.0	0.0	-11.8	-13.6	($1)	
	NOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CH4	0.0	0.0	0.0	-0.0	-0.0	($0)	
	SOx	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	TSP	-0.0	0.0	0.0	-0.0	-0.0	($0)	
	CO	0.0	0.0	0.0	-0.0	-0.0	($0)	
	VOC	-0.0	0.0	0.0	-0.0	-0.0	($0)	

TRIOEEH	Energy	423.4	0.0	0.0	0.0	423.4	$5	$29
	CO2	114.3	0.0	0.0	0.0	114.3	$5	
	NOx	0.2	0.0	0.0	0.0	0.2	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.6	0.0	0.0	0.0	0.6	$0	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRIOASH	Energy	-490.3	0.0	0.0	0.0	-490.3	($6)	($33)
	CO2	-132.4	0.0	0.0	0.0	-132.4	($5)	
	NOx	-0.2	0.0	0.0	0.0	-0.2	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-0.6	0.0	0.0	0.0	-0.6	($0)	
	TSP	-0.1	0.0	0.0	0.0	-0.1	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TRIOGSH	Energy	-3893.0	0.0	0.0	0.0	-3893.0	($46)	($265)
	CO2	-1051.1	0.0	0.0	0.0	-1051.1	($42)	
	NOx	-1.9	0.0	0.0	0.0	-1.9	($0)	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	-5.1	0.0	0.0	0.0	-5.1	($4)	
	TSP	-0.6	0.0	0.0	0.0	-0.6	($0)	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	-0.0	0.0	0.0	0.0	-0.0	($0)	
TRIOMOF	Energy	386.3	0.0	11166.0	0.0	11552.3	$39	$222
	CO2	104.3	0.0	815.1	0.0	919.4	$37	
	NOx	0.2	0.0	0.3	0.0	0.5	$0	
	CH4	0.0	0.0	0.1	0.0	0.1	$0	
	SOx	0.5	0.0	1.0	0.0	1.6	$1	
	TSP	0.1	0.0	0.1	0.0	0.1	$0	
	CO	0.0	0.0	0.1	0.0	0.1	$0	
	VOC	0.0	0.0	0.1	0.0	0.1	$0	
TRIOMPF	Energy	386.3	11166.0	0.0	0.0	11552.3	$30	$173
	CO2	104.3	629.8	0.0	0.0	734.1	$29	
	NOx	0.2	0.7	0.0	0.0	0.9	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.5	0.0	0.0	0.0	0.5	$0	
	TSP	0.1	0.0	0.0	0.0	0.1	$0	
	CO	0.0	0.1	0.0	0.0	0.1	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRIOMGF	Energy	0.7	0.0	0.0	117.0	117.7	$0	$1
	CO2	0.2	0.0	0.0	6.0	6.2	$0	
	NOx	0.0	0.0	0.0	0.0	0.0	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.0	0.0	0.0	0.0	0.0	$0	
	TSP	0.0	0.0	0.0	0.0	0.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	
TRIOHGF	Energy	0.7	0.0	0.0	101.4	102.1	$0	$1
	CO2	0.2	0.0	0.0	5.2	5.4	$0	
	NOx	0.0	0.0	0.0	0.0	0.0	$0	
	CH4	0.0	0.0	0.0	0.0	0.0	$0	
	SOx	0.0	0.0	0.0	0.0	0.0	$0	
	TSP	0.0	0.0	0.0	0.0	0.0	$0	
	CO	0.0	0.0	0.0	0.0	0.0	$0	
	VOC	0.0	0.0	0.0	0.0	0.0	$0	

ANNUAL ENERGY & EMISSION SAVINGS - ZONE 2/A

Space Heating Emissions Production (kg/year)

HOUSE ID		ELECTRICITY (MJ)	PROPANE (MJ)	OIL (MJ)	NATURAL GAS (MJ)	TOTAL	COST	PRESENT VALUE
STLOEEH	Energy	3580.920	0.000	0.000	0.000	3580.920	$42	$244
	CO2	966.848	0.000	0.000	0.000	966.848	$39	
	NOx	1.719	0.000	0.000	0.000	1.719	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	4.655	0.000	0.000	0.000	4.655	$3	
	TSP	0.537	0.000	0.000	0.000	0.537	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.011	0.000	0.000	0.000	0.011	$0	
STLOASH	Energy	250.560	0.000	0.000	0.000	250.560	$3	$17
	CO2	67.651	0.000	0.000	0.000	67.651	$3	
	NOx	0.120	0.000	0.000	0.000	0.120	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.326	0.000	0.000	0.000	0.326	$0	
	TSP	0.038	0.000	0.000	0.000	0.038	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.001	0.000	0.000	0.000	0.001	$0	
STLOGSH	Energy	-3324.880	0.000	0.000	0.000	-3324.880	($39)	($227)
	CO2	-897.718	0.000	0.000	0.000	-897.718	($36)	
	NOx	-1.596	0.000	0.000	0.000	-1.596	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-4.322	0.000	0.000	0.000	-4.322	($3)	
	TSP	-0.499	0.000	0.000	0.000	-0.499	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.010	0.000	0.000	0.000	-0.010	($0)	
STLOMOF	Energy	300.240	0.000	21314.000	0.000	21614.240	$69	$395
	CO2	81.065	0.000	1555.922	0.000	1636.987	$65	
	NOx	0.144	0.000	0.618	0.000	0.762	$0	
	CH4	0.000	0.000	0.107	0.000	0.107	$0	
	SOx	0.390	0.000	2.004	0.000	2.394	$2	
	TSP	0.045	0.000	0.171	0.000	0.216	$0	
	CO	0.000	0.000	0.277	0.000	0.277	$0	
	VOC	0.001	0.000	0.171	0.000	0.171	$1	
STLOMPF	Energy	300.240	21314.000	0.000	0.000	21614.240	$52	$301
	CO2	81.065	1202.110	0.000	0.000	1283.174	$51	
	NOx	0.144	1.362	0.000	0.000	1.506	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.390	0.001	0.000	0.000	0.392	$0	
	TSP	0.045	0.040	0.000	0.000	0.085	$0	
	CO	0.000	0.120	0.000	0.000	0.120	$0	
	VOC	0.001	0.048	0.000	0.000	0.049	$0	
STLOMGF	Energy	182.400	0.000	0.000	10837.000	11019.400	$25	$141
	CO2	49.248	0.000	0.000	552.687	601.935	$24	
	NOx	0.088	0.000	0.000	0.303	0.391	$0	
	CH4	0.000	0.000	0.000	0.011	0.011	$0	
	SOx	0.237	0.000	0.000	0.004	0.241	$0	
	TSP	0.027	0.000	0.000	0.065	0.092	$0	
	CO	0.000	0.000	0.000	0.076	0.076	$0	
	VOC	0.001	0.000	0.000	0.033	0.033	$0	
STLOHGF	Energy	182.400	0.000	0.000	-608.333	-425.933	$1	$5
	CO2	49.248	0.000	0.000	-31.025	18.223	$1	
	NOx	0.088	0.000	0.000	-0.017	0.071	$0	
	CH4	0.000	0.000	0.000	-0.001	-0.001	($0)	
	SOx	0.237	0.000	0.000	-0.000	0.237	$0	
	TSP	0.027	0.000	0.000	-0.004	0.024	$0	
	CO	0.000	0.000	0.000	-0.004	-0.004	($0)	
	VOC	0.001	0.000	0.000	-0.002	-0.001	($0)	

STSOEEH	Energy	2415.600	0.000	0.000	0.000	2415.600	$29	$165
	CO2	652.212	0.000	0.000	0.000	652.212	$26	
	NOx	1.159	0.000	0.000	0.000	1.159	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	3.140	0.000	0.000	0.000	3.140	$2	
	TSP	0.362	0.000	0.000	0.000	0.362	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.007	0.000	0.000	0.000	0.007	$0	
STSOASH	Energy	91.080	0.000	0.000	0.000	91.080	$1	$6
	CO2	24.592	0.000	0.000	0.000	24.592	$1	
	NOx	0.044	0.000	0.000	0.000	0.044	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.118	0.000	0.000	0.000	0.118	$0	
	TSP	0.014	0.000	0.000	0.000	0.014	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.000	0.000	0.000	0.000	0.000	$0	
STSOGSH	Energy	-2801.360	0.000	0.000	0.000	-2801.360	($33)	($191)
	CO2	-756.367	0.000	0.000	0.000	-756.367	($30)	
	NOx	-1.345	0.000	0.000	0.000	-1.345	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-3.642	0.000	0.000	0.000	-3.642	($3)	
	TSP	-0.420	0.000	0.000	0.000	-0.420	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.008	0.000	0.000	0.000	-0.008	($0)	
STSOMOF	Energy	360.360	0.000	19389.000	0.000	19749.360	$64	$365
	CO2	97.297	0.000	1415.397	0.000	1512.694	$61	
	NOx	0.173	0.000	0.562	0.000	0.735	$0	
	CH4	0.000	0.000	0.097	0.000	0.097	$0	
	SOx	0.468	0.000	1.823	0.000	2.291	$2	
	TSP	0.054	0.000	0.155	0.000	0.209	$0	
	CO	0.000	0.000	0.252	0.000	0.252	$0	
	VOC	0.001	0.000	0.155	0.000	0.156	$1	
STSOMPF	Energy	360.360	19389.000	0.000	0.000	19749.360	$49	$279
	CO2	97.297	1093.540	0.000	0.000	1190.837	$48	
	NOx	0.173	1.239	0.000	0.000	1.412	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.468	0.001	0.000	0.000	0.470	$0	
	TSP	0.054	0.036	0.000	0.000	0.091	$0	
	CO	0.000	0.109	0.000	0.000	0.109	$0	
	VOC	0.001	0.044	0.000	0.000	0.045	$0	
STSOMGF	Energy	230.800	0.000	0.000	10926.000	11156.800	$25	$146
	CO2	62.316	0.000	0.000	557.226	619.542	$25	
	NOx	0.111	0.000	0.000	0.306	0.417	$0	
	CH4	0.000	0.000	0.000	0.011	0.011	$0	
	SOx	0.300	0.000	0.000	0.004	0.304	$0	
	TSP	0.035	0.000	0.000	0.066	0.100	$0	
	CO	0.000	0.000	0.000	0.076	0.076	$0	
	VOC	0.001	0.000	0.000	0.033	0.033	$0	
STSOHGF	Energy	230.800	0.000	0.000	9486.333	9717.133	$22	$129
	CO2	62.316	0.000	0.000	483.803	546.119	$22	
	NOx	0.111	0.000	0.000	0.266	0.376	$0	
	CH4	0.000	0.000	0.000	0.009	0.009	$0	
	SOx	0.300	0.000	0.000	0.004	0.304	$0	
	TSP	0.035	0.000	0.000	0.057	0.092	$0	
	CO	0.000	0.000	0.000	0.066	0.066	$0	
	VOC	0.001	0.000	0.000	0.028	0.029	$0	

SBSOEEH	Energy	3538.800	0.000	0.000	0.000	3538.800	$42	$241
	CO2	955.476	0.000	0.000	0.000	955.476	$38	
	NOx	1.699	0.000	0.000	0.000	1.699	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	4.600	0.000	0.000	0.000	4.600	$3	
	TSP	0.531	0.000	0.000	0.000	0.531	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.011	0.000	0.000	0.000	0.011	$0	
SBSOASH	Energy	584.640	0.000	0.000	0.000	584.640	$7	$40
	CO2	157.853	0.000	0.000	0.000	157.853	$6	
	NOx	0.281	0.000	0.000	0.000	0.281	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.760	0.000	0.000	0.000	0.760	$1	
	TSP	0.088	0.000	0.000	0.000	0.088	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.002	0.000	0.000	0.000	0.002	$0	
SBSOGSH	Energy	-1032.200	0.000	0.000	0.000	-1032.200	($12)	($70)
	CO2	-278.694	0.000	0.000	0.000	-278.694	($11)	
	NOx	-0.495	0.000	0.000	0.000	-0.495	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-1.342	0.000	0.000	0.000	-1.342	($1)	
	TSP	-0.155	0.000	0.000	0.000	-0.155	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.003	0.000	0.000	0.000	-0.003	($0)	
SBSOMOF	Energy	310.680	0.000	16822.000	0.000	17132.680	$55	$316
	CO2	83.884	0.000	1228.006	0.000	1311.890	$52	
	NOx	0.149	0.000	0.488	0.000	0.637	$0	
	CH4	0.000	0.000	0.084	0.000	0.084	$0	
	SOx	0.404	0.000	1.581	0.000	1.985	$1	
	TSP	0.047	0.000	0.135	0.000	0.181	$0	
	CO	0.000	0.000	0.219	0.000	0.219	$0	
	VOC	0.001	0.000	0.135	0.000	0.136	$1	
SBSOMPF	Energy	310.680	16822.000	0.000	0.000	17132.680	$42	$242
	CO2	83.884	948.761	0.000	0.000	1032.644	$41	
	NOx	0.149	1.075	0.000	0.000	1.224	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.404	0.001	0.000	0.000	0.405	$0	
	TSP	0.047	0.032	0.000	0.000	0.078	$0	
	CO	0.000	0.095	0.000	0.000	0.095	$0	
	VOC	0.001	0.038	0.000	0.000	0.039	$0	
SBSOMGF	Energy	256.000	0.000	0.000	6394.000	6650.000	$16	$94
	CO2	69.120	0.000	0.000	326.094	395.214	$16	
	NOx	0.123	0.000	0.000	0.179	0.302	$0	
	CH4	0.000	0.000	0.000	0.006	0.006	$0	
	SOx	0.333	0.000	0.000	0.003	0.335	$0	
	TSP	0.038	0.000	0.000	0.038	0.077	$0	
	CO	0.000	0.000	0.000	0.045	0.045	$0	
	VOC	0.001	0.000	0.000	0.019	0.020	$0	
SBSOHGF	Energy	256.000	0.000	0.000	5541.467	5797.467	$15	$83
	CO2	69.120	0.000	0.000	282.615	351.735	$14	
	NOx	0.123	0.000	0.000	0.155	0.278	$0	
	CH4	0.000	0.000	0.000	0.006	0.006	$0	
	SOx	0.333	0.000	0.000	0.002	0.335	$0	
	TSP	0.038	0.000	0.000	0.033	0.072	$0	
	CO	0.000	0.000	0.000	0.039	0.039	$0	
	VOC	0.001	0.000	0.000	0.017	0.017	$0	

SSDOEEH	Energy	2206.800	0.000	0.000	0.000	2206.800	$26	$150
	CO2	595.836	0.000	0.000	0.000	595.836	$24	
	NOx	1.059	0.000	0.000	0.000	1.059	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	2.869	0.000	0.000	0.000	2.869	$2	
	TSP	0.331	0.000	0.000	0.000	0.331	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.007	0.000	0.000	0.000	0.007	$0	
SSDOASH	Energy	205.200	0.000	0.000	0.000	205.200	$2	$14
	CO2	55.404	0.000	0.000	0.000	55.404	$2	
	NOx	0.098	0.000	0.000	0.000	0.098	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.267	0.000	0.000	0.000	0.267	$0	
	TSP	0.031	0.000	0.000	0.000	0.031	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.001	0.000	0.000	0.000	0.001	$0	
SSDOGSH	Energy	-2196.600	0.000	0.000	0.000	-2196.600	($26)	($150)
	CO2	-593.082	0.000	0.000	0.000	-593.082	($24)	
	NOx	-1.054	0.000	0.000	0.000	-1.054	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-2.856	0.000	0.000	0.000	-2.856	($2)	
	TSP	-0.329	0.000	0.000	0.000	-0.329	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.007	0.000	0.000	0.000	-0.007	($0)	
SSDOMOF	Energy	381.960	0.000	18321.000	0.000	18702.960	$61	$348
	CO2	103.129	0.000	1337.433	0.000	1440.562	$58	
	NOx	0.183	0.000	0.531	0.000	0.715	$0	
	CH4	0.000	0.000	0.092	0.000	0.092	$0	
	SOx	0.497	0.000	1.722	0.000	2.219	$2	
	TSP	0.057	0.000	0.147	0.000	0.204	$0	
	CO	0.000	0.000	0.238	0.000	0.238	$0	
	VOC	0.001	0.000	0.147	0.000	0.148	$1	
SSDOMPF	Energy	381.960	18321.000	0.000	0.000	18702.960	$46	$267
	CO2	103.129	1033.304	0.000	0.000	1136.434	$45	
	NOx	0.183	1.171	0.000	0.000	1.354	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.497	0.001	0.000	0.000	0.498	$0	
	TSP	0.057	0.034	0.000	0.000	0.092	$0	
	CO	0.000	0.103	0.000	0.000	0.103	$0	
	VOC	0.001	0.041	0.000	0.000	0.043	$0	
SSDOMGF	Energy	265.680	0.000	0.000	11778.000	12043.680	$28	$158
	CO2	71.734	0.000	0.000	600.678	672.412	$27	
	NOx	0.128	0.000	0.000	0.330	0.457	$0	
	CH4	0.000	0.000	0.000	0.012	0.012	$0	
	SOx	0.345	0.000	0.000	0.005	0.350	$0	
	TSP	0.040	0.000	0.000	0.071	0.111	$0	
	CO	0.000	0.000	0.000	0.082	0.082	$0	
	VOC	0.001	0.000	0.000	0.035	0.036	$0	
SSDOHGF	Energy	65.680	0.000	0.000	10208.067	10273.747	$22	$126
	CO2	17.734	0.000	0.000	520.611	538.345	$22	
	NOx	0.032	0.000	0.000	0.286	0.317	$0	
	CH4	0.000	0.000	0.000	0.010	0.010	$0	
	SOx	0.085	0.000	0.000	0.004	0.089	$0	
	TSP	0.010	0.000	0.000	0.061	0.071	$0	
	CO	0.000	0.000	0.000	0.071	0.071	$0	
	VOC	0.000	0.000	0.000	0.031	0.031	$0	

SREOEEH	Energy	1553.040	0.000	0.000	0.000	1553.040	$18	$106
	CO2	419.321	0.000	0.000	0.000	419.321	$17	
	NOx	0.745	0.000	0.000	0.000	0.745	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	2.019	0.000	0.000	0.000	2.019	$1	
	TSP	0.233	0.000	0.000	0.000	0.233	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.005	0.000	0.000	0.000	0.005	$0	
SREOASH	Energy	109.440	0.000	0.000	0.000	109.440	$1	$7
	CO2	29.549	0.000	0.000	0.000	29.549	$1	
	NOx	0.053	0.000	0.000	0.000	0.053	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.142	0.000	0.000	0.000	0.142	$0	
	TSP	0.016	0.000	0.000	0.000	0.016	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.000	0.000	0.000	0.000	0.000	$0	
SREOGSH	Energy	-2190.600	0.000	0.000	0.000	-2190.600	($26)	($149)
	CO2	-591.462	0.000	0.000	0.000	-591.462	($24)	
	NOx	-1.051	0.000	0.000	0.000	-1.051	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-2.848	0.000	0.000	0.000	-2.848	($2)	
	TSP	-0.329	0.000	0.000	0.000	-0.329	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.007	0.000	0.000	0.000	-0.007	($0)	
SREOMOF	Energy	424.440	0.000	17998.000	0.000	18422.440	$60	$345
	CO2	114.599	0.000	1313.854	0.000	1428.453	$57	
	NOx	0.204	0.000	0.522	0.000	0.726	$0	
	CH4	0.000	0.000	0.090	0.000	0.090	$0	
	SOx	0.552	0.000	1.692	0.000	2.244	$2	
	TSP	0.064	0.000	0.144	0.000	0.208	$0	
	CO	0.000	0.000	0.234	0.000	0.234	$0	
	VOC	0.001	0.000	0.144	0.000	0.145	$1	
SREOMPF	Energy	424.440	17998.000	0.000	0.000	18422.440	$46	$265
	CO2	114.599	1015.087	0.000	0.000	1129.686	$45	
	NOx	0.204	1.150	0.000	0.000	1.354	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.552	0.001	0.000	0.000	0.553	$0	
	TSP	0.064	0.034	0.000	0.000	0.098	$0	
	CO	0.000	0.102	0.000	0.000	0.102	$0	
	VOC	0.001	0.041	0.000	0.000	0.042	$0	
SREOMGF	Energy	287.600	0.000	0.000	11328.000	11615.600	$27	$154
	CO2	77.652	0.000	0.000	577.728	655.380	$26	
	NOx	0.138	0.000	0.000	0.317	0.455	$0	
	CH4	0.000	0.000	0.000	0.011	0.011	$0	
	SOx	0.374	0.000	0.000	0.005	0.378	$0	
	TSP	0.043	0.000	0.000	0.068	0.111	$0	
	CO	0.000	0.000	0.000	0.079	0.079	$0	
	VOC	0.001	0.000	0.000	0.034	0.035	$0	
SREOHGF	Energy	287.600	0.000	0.000	9817.667	10105.267	$24	$136
	CO2	77.652	0.000	0.000	500.701	578.353	$23	
	NOx	0.138	0.000	0.000	0.275	0.413	$0	
	CH4	0.000	0.000	0.000	0.010	0.010	$0	
	SOx	0.374	0.000	0.000	0.004	0.378	$0	
	TSP	0.043	0.000	0.000	0.059	0.102	$0	
	CO	0.000	0.000	0.000	0.069	0.069	$0	
	VOC	0.001	0.000	0.000	0.029	0.030	$0	

SRIOEEH	Energy	1099.080	0.000	0.000	0.000	1099.080	$13	$75
	CO2	296.752	0.000	0.000	0.000	296.752	$12	
	NOx	0.528	0.000	0.000	0.000	0.528	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	1.429	0.000	0.000	0.000	1.429	$1	
	TSP	0.165	0.000	0.000	0.000	0.165	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.003	0.000	0.000	0.000	0.003	$0	
SRIOASH	Energy	200.160	0.000	0.000	0.000	200.160	$2	$14
	CO2	54.043	0.000	0.000	0.000	54.043	$2	
	NOx	0.096	0.000	0.000	0.000	0.096	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.260	0.000	0.000	0.000	0.260	$0	
	TSP	0.030	0.000	0.000	0.000	0.030	$0	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	0.001	0.000	0.000	0.000	0.001	$0	
SRIOGSH	Energy	-2822.400	0.000	0.000	0.000	-2822.400	($33)	($192)
	CO2	-762.048	0.000	0.000	0.000	-762.048	($30)	
	NOx	-1.355	0.000	0.000	0.000	-1.355	($0)	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	-3.669	0.000	0.000	0.000	-3.669	($3)	
	TSP	-0.423	0.000	0.000	0.000	-0.423	($0)	
	CO	0.000	0.000	0.000	0.000	0.000	$0	
	VOC	-0.008	0.000	0.000	0.000	-0.008	($0)	
SRIOMOF	Energy	399.600	0.000	14500.000	0.000	14899.600	$49	$282
	CO2	107.892	0.000	1058.500	0.000	1166.392	$47	
	NOx	0.192	0.000	0.421	0.000	0.612	$0	
	CH4	0.000	0.000	0.073	0.000	0.073	$0	
	SOx	0.519	0.000	1.363	0.000	1.882	$1	
	TSP	0.060	0.000	0.116	0.000	0.176	$0	
	CO	0.000	0.000	0.189	0.000	0.189	$0	
	VOC	0.001	0.000	0.116	0.000	0.117	$1	
SRIOMPF	Energy	399.600	14500.000	0.000	0.000	14899.600	$38	$218
	CO2	107.892	817.800	0.000	0.000	925.692	$37	
	NOx	0.192	0.927	0.000	0.000	1.118	$0	
	CH4	0.000	0.000	0.000	0.000	0.000	$0	
	SOx	0.519	0.001	0.000	0.000	0.520	$0	
	TSP	0.060	0.027	0.000	0.000	0.087	$0	
	CO	0.000	0.082	0.000	0.000	0.082	$0	
	VOC	0.001	0.033	0.000	0.000	0.034	$0	
SRIOMGF	Energy	307.440	0.000	0.000	10450.000	10757.440	$25	$145
	CO2	83.009	0.000	0.000	532.950	615.959	$25	
	NOx	0.148	0.000	0.000	0.293	0.440	$0	
	CH4	0.000	0.000	0.000	0.010	0.010	$0	
	SOx	0.400	0.000	0.000	0.004	0.404	$0	
	TSP	0.046	0.000	0.000	0.063	0.109	$0	
	CO	0.000	0.000	0.000	0.073	0.073	$0	
	VOC	0.001	0.000	0.000	0.031	0.032	$0	
SRIOHGF	Energy	307.440	0.000	0.000	9056.600	9364.040	$22	$129
	CO2	83.009	0.000	0.000	461.887	544.895	$22	
	NOx	0.148	0.000	0.000	0.254	0.401	$0	
	CH4	0.000	0.000	0.000	0.009	0.009	$0	
	SOx	0.400	0.000	0.000	0.004	0.403	$0	
	TSP	0.046	0.000	0.000	0.054	0.100	$0	
	CO	0.000	0.000	0.000	0.063	0.063	$0	
	VOC	0.001	0.000	0.000	0.027	0.028	$0	

Appendix V

Housing Development and
Buildings Branch
777 Bay Street 2nd Floor
Toronto, ON M5G 2E5

Tel: (416) 585-6668
Fax: (416) 585-4029

March 3, 1995

Mr. Peter G. Large
Executive Director
Professional Engineers Ontario
25 Sheppard Avenue West
Suite 1000
North York, Ontario
M2N 6S9

Dear Mr. Large,

The Ministry of Housing in conjunction with Ontario Hydro, Ministry of Environment and Energy as well as Consumers Gas have initiated two joint projects to study the incremental impacts of the proposed "National Energy Code for Buildings 1995" (NECB 1995) and the "National Energy Code for Houses 1995" (NECH 1995) in Ontario.

The NECB 1995 and NECH 1995 are being developed by the National Research Council of Canada and are expected to be part of the 1995 edition of the National Building Code of Canada. The National Energy Codes will reflect individual provincial interests with the expectation that these energy codes will be adopted in provincial building codes across the country.

As part of the code development process for considering the implementation of these National Energy Codes into the OBC, Ontario has initiated two joint projects that will examine the incremental impact (on cost and energy use) of these energy codes compared to the current provisions of the OBC. The projects will also investigate the impact on the building industry from a construction perspective in terms of design/build practicality as well as from an enforcement perspective in terms of ensuring compliance.

.../2

As the projects near completion, the Housing Development and Buildings Branch (HDBB) of the Ministry is undertaking preliminary consultation with key stakeholders by organizing focus group meetings for each of the energy codes. The Ministry is seeking your participation in reviewing the study being conducted on the **NECH 1995**.

The meeting is scheduled for Friday April 7th, 1995. The terms of reference, meeting location as well as a summary of the consultant's findings will be forwarded to your representative a week prior to the scheduled meeting. It is requested that the Ministry receive your organization's representative (name, address, telephone number) before March 24, 1995.

A similar meeting has been scheduled for Friday March 31, 1995 to review the study being conducted on the NECB 1995.

I look forward to the valuable contribution your organization will make in this review process. Should you have any questions, please do not hesitate to contact me.

Sincerely,

Ali Arlani
Manager
Code Development and Technical Training Section

Ali Arlani/Buildings Branch
RDG\C:\WP\WPDATA\ENERCODE.TF\NECH-TF.1

Ontario

Housing Development and
Buildings Branch
777 Bay Street 2nd Floor
Toronto, ON M5G 2E5

Ministry of Housing Ministère du Logement

Tel: (416) 585-6668
Fax: (416) 585-4029

April 4, 1995

RE: Focus Group Meeting on National Energy Code for Houses 1995

Attention: Focus Group Participants

Enclosed please find a copy of the agenda for the focus group meeting on the National Energy Code for Houses 1995 scheduled for Friday April 7, 1995. I have also attached a stakeholder information package.

The meeting is scheduled for Friday April 7, 1995 between 9:00 am and 2:30 pm and will be held in the Frontenac Room in the MacDonald Block Building located at 77 Wellesley Street West, Toronto. Coffee and muffins will be available at 8:30 am.

I look forward to the valuable contribution your organization will make in this review process. Should you have any questions, please do not hesitate to contact me.

Sincerely,

Ralph Di Gaetano

for Ali Arlani
Manager
Code Development and Technical Training Section

Attachments

AGENDA

STAKEHOLDER MEETING

The Implications of Adopting the National Energy Code for Housing in Ontario

9:00 a.m.
April 7, 1995

MacDonald Block, Frontenac Room
Queen's Park, Toronto

9:00 a.m.	*Introductions*
9:15 a.m.	*Objectives of the Meeting*
9:30 a.m.	*NECH Overview and other NRC Initiatives (John Haysom)*
9:45 a.m.	*Summary of Ontario Study Findings*
10:30 a.m.	*break*
10:45 a.m.	*Breakout of Discussion Groups*
12:00 noon	*lunch*
12:30 p.m.	*Presentation of Discussion Group Summaries*
1:30 p.m.	*Group Discussion*
2:30 p.m.	*Adjournment*

Stakeholder Information Package

IMPLICATIONS OF ADOPTING THE NATIONAL ENERGY CODE FOR HOUSING IN ONTARIO

9:00 a.m.
April 7, 1995

MacDonald Block, Frontenac Room
Queen's Park, Toronto

BACKGROUND

In 1995 the Canadian Commission on Building and Fire Codes will publish a model National Energy Code for Houses (NECH). If adopted by the provinces, the Code will require that all new houses meet or exceed minimum standards for energy efficiency. The NECH provides for each province or territory to have its own minimum standards, taking into account climate and regional energy and construction costs. In other words, the requirements for colder areas in the country and for houses heated with more expensive energy sources are more stringent.

The NECH will apply to all new buildings of residential occupancy that currently conform to the height and building area limits of Part 9 of the National Building Code; that is, buildings that are three storeys or less in height and that have a building area that does not exceeds 600 m^2 (6450 ft^2). The NECH does not apply to buildings where heating equipment is not installed, such as summer cottages.

The scope of the National Energy Code for Houses includes requirements for the building envelope, space heating and cooling equipment, mechanical ventilation, service water heating systems, lighting and electric power requirements.

There are three ways to comply with the requirements of the NECH: prescriptive compliance; trade-off compliance; and performance compliance. The prescriptive approach is like Part 9 of the Ontario Building Code (OBC), with simple to follow tables. The trade-off approach allows for more efficient equipment or insulation to be traded off against less efficient construction (for example, better windows, less wall insulation), and some minor calculations will be required. The trade-off approach, much like 9.38 Thermal Design in the OBC, requires documentation of equivalency. The NECH also offers a performance path that permits the most flexibility in meeting its requirements. Builders may choose whatever path is most cost effective for the way they build.

On the pages which follow, information is being provided to allow the building industry to become aware of the implications of adopting the 1995 National Energy Code for Housing in Ontario. After considering this information, it is hoped that stakeholders, like yourself, will take the time to participate in a forum to discuss your views.

IMPLICATIONS

The implications to the building industry have been broken down into several broad categories:

- ***First Costs Implications*** - the difference in costs associated with the adoption of the NECH in Ontario;
- ***Changes in Construction Practice*** - impacts on how you build your houses;
- ***Code Enforcement*** - plans, permits, inspections and the technical documentation which will be required; and
- ***Administration, Supervision, Co-ordination*** - the implications for paperwork, site supervision and dealing with suppliers of equipment and materials.

A number of of other implications will be provided which relate to:

- **Life Cycle Costs** - the implications of the NECH on the total cost of the building across its expected life; and
- **Environmental Implications** - the greenhouse gas and other emission impacts of NECH adoption.

First Costs Implications

All first costs implications have been referenced to a two storey, 2,100 ft^2 dwelling located in Zone 1 (southern Ontario) where most of the housing starts in Ontario occur. Cost differences are generally greater in Zone 2 (northern Ontario).

The soon to be released study, *The Implications of Adopting the National Energy Code for Housing in Ontario,* reviews the cost implications for six house types in southern and northern Ontario

Building Envelope

There is practically no difference between OBC and NECH requirements for electrically heated homes, and homes with air source and ground source heat pumps. For electrically heated houses the NECH requires somewhat higher levels of attic insulation, while windows would likely need to be gas charged to meet the prescriptive requirements.

Homes heated with oil or propane would cost about $1,200 more in added insulation and better windows. Adoption of the NECH would have the greatest impact on this class of homes.

Natural gas heated homes would be practically the same under the OBC or the NECH. NECH provisions would likely require low-E windows for all gas heated houses.

Heating Systems

There is no change in the cost of heating systems since the same minimum efficiencies for appliances are required in the NECH as it references provincial energy efficiency acts. Setback thermostats, however, are required under the NECH, and the added cost of this requirement has been estimated to range between $100 and $250, depending on the type of equipment being controlled. As well, motorized dampers are required on fresh air intakes, and this can cost about $150 more.

Mechanical Ventilation

Heat recovery ventilation is required for all fuel types, except natural gas and ground source heat pumps, under the NECH in Zone 1. Compared with present OBC requirements, this means that all oil and propane heated homes will have to come equipped with HRVs, at an estimated premium of about $600.

Exterior Lighting

Exterior lighting controls are required under the NECH for every outdoor lighting fixture. It has been estimated that this could cost as much as $60 extra per outdoor lighting fixture.

Plumbing and Electrical

There are no significant impacts in terms of plumbing an electrical associated with adoption of the NECH.

Changes In Construction Practice

Building Envelope

Beginning with basements, there are no significant changes in how basements would be insulated under the NECH. All insulation values noted within the NECH are effective thermal resistances. These must be used instead of the nominal values presently used in the OBC. Builders and building officials will need to apply the NECH's *Appendix C, Method for Calculating the Thermal Resistance of Building Assemblies* to determine the necessary values. Further, the NECH requires the insulation be installed continuously, meaning that exterior fireplaces would have to be insulated. The airtightness of the dwelling must now be visibly attained, that is, an inspector must be able to see that all leaks and penetrations are sealed, otherwise he or she may require an airtightness test to be performed as a measure of compliance.

Heating Systems

Except for the provision of setback thermostats, practically speaking there are no impacts on heating system design or installation under the NECH.

Mechanical Ventilation

There are no significant impacts on mechanical ventilation system design or installation under the NECH, however, motorized dampers are required on any fresh air intakes to the building.

Plumbing and Electrical

There is no practical difference between the requirements of the OBC and the NECH with respect to plumbing and electrical work.

Life Cycle Costing Results

In general, the NECH would provide insignificant energy and life cycle cost savings for the vast majority of new home buyers in Ontario. Nonetheless, it would provide savings to new home purchasers whose buildings are heated with oil, propane and in most cases for those using heat pumps, both air and ground source. At the present time, for gas and electrically heated homes in Ontario there are no significant life cycle cost benefits from moving form the Ontario Building Code to the National Building Code for Housing in Ontario.

Environmental Implications

Adoption of the NECH provides limited environmental benefits for oil and propane-heated buildings. For the majority of new houses in Ontario moving to the NECH provides insignificant environmental benefits.

Code Enforcement

Plans/Documentation

Plans would generally have to be of higher quality permitting reviewers to check effective thermal resistance values. As well, documentation for insulation and window products may also be required. Additional costs for better plans and documentation will vary depending on how many houses are built using the same set of plans and documentation.

Permits

Due to a number of additional items to be enforced under the NECH compared with the OBC, it is likely that permit fees will increase somewhat. This depends on the level of Code enforcement presently provided in the community.

Inspections/Testing

Inspections should not be significantly different under the NECH requirements, however, they may take a little longer and cover more items. Depending on how the airtightness requirements of the NECH are interpreted, airtightness testing may be required in some municipalities, particularly when the trade-off or performance compliance paths are chosen. The cost of airtightness testing can range from $150 to $350.

Administration, Supervision, Co-Ordination

Paperwork/Documentation

There will probably be a slight increase in paperwork handling, particularly for the documentation of equipment efficiencies, window performance and insulation effectiveness data. This will further increase if the trade-off or performance compliance paths are chosen.

Quality Assurance

Site supervision may be required at a higher level than is currently provided in terms of air barrier installation. This may only be a temporary increase in time spent on site supervision, which may return to normal levels once trades have adjusted to the requirements.

Suppliers and Availability

The window industry may be slow to respond to improved window performance requirements, and the selection of products, along with competitive pricing, may dwindle during the transition period from present to NECH requirements.

KEY BUILDING INDUSTRY CONSIDERATIONS

To put it all in perspective, the building industry, and particulary builders, will need to determine which of the impacts apply to their business, and how much of a difference this will make. Some key considerations include:

- What are the implications for your organization, members or constituents should Ontario reference the NECH within the OBC?
- What level of interest is there for using trade-offs and performance assessments, particularly as a means of getting credit for innovation? What problems do you forsee (if any) in the adoption of a tradeoff and performance compliance path?
- Will the higher window standards of the NECH pose a problem for the industry?
- Will the NECH pose any problems for the HRV industry?
- How critical is the difference in costs associated with the NECH to business operations? In other words, what is the maximum threshold for construction cost increases on a per house basis?
- Additional paperwork and documentation may be required with the adoption of the NECH. Will this impose on undue burden on the industry?
- Do changes to Codes affect on-site productivity? Will this have an impact on construction costs?
- Should Ontario proceed with the adoption of the NECH?
- What should the next steps be?

These points, along with your own personal concerns, are the sorts of issues associated with the adoption of the NECH that you may wish to consider.

You input to the process is important and valued. If you are unable to attend the forum, your views may be forwarded in writing to:

Habitechnica,
88 Prince Arthur Avenue, Suite 300
Toronto, Ontario, M5R 1B6
phone: (416) 961-3487, fax (416) 975-8819

Ontario

Ministry of Housing   Ministère du Logement

Housing Development and
Buildings Branch
777 Bay Street 2nd Floor
Toronto, ON M5G 2E5

Tel: (416) 585-6668
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April 13, 1995

<u>RE: Building Official Focus Group Meeting on National Energy Code for Buildings 1995 and National Energy Code for Houses 1995</u>

Attention: Focus Group Participants

Enclosed please find a copy of the agenda for the focus group meeting on the NECB 1995 and NECH 1995 scheduled for Thursday April 20, 1995. I have also attached a stakeholder information package.

The meeting is scheduled for Thursday April 20, 1995 between 9:00 am and 4:00 pm and will be held in Boardroom 10B at the Ministry of Housing located at 777 Street, Toronto. Coffee and muffins will be available at 8:30 am.

I look forward to the valuable contribution your organization will make in this review process. Should you have any questions, please do not hesitate to contact me.

Sincerely,

Ralph Di Gaetano

for Ali Arlani
Manager
Code Development and Technical Training Section

Attachments

1150 (05/93)

AGENDA

Focus Group Meeting on NECB 1995 and NECH 1995

Boardroom 10B
Ministry of Housing
777 Bay Street, Toronto

9:00 am to 4:00 pm
Thursday April 20, 1995

NECB 1995

9:00 am	Introduction (Ministry of Housing)
9:15 am	Overview of Implementation Options (CEF)
9:45 am	Report on Ontario Building Officials Survey (EIL)
10:15 am	Discussion of ASHRAE/IES 90.1 Compliance Review and Inspection Manual (EIL)
10:30 am	Break
10:45 am	Review of NECB Impacts (EIL)
11:10 am	Breakout Group Discussions (All)
11:50 am	Group Reports (All)
12:00 noon	Lunch

NECH 1995

12:30 pm	Summary of Ontario NECH Study Findings
1:15 pm	Breakout Group Discussions (all)
2:30 pm	Break
2:45 pm	Presentation of Group Discussions
3:30 pm	Open Discussion
4:00 pm	Adjournment

Workshop to Discuss

ASHRAE/IES 90.1-1989

(Plus the Ontario Guidelines and the National Energy Code for Buildings 1995)

Question No. 1.

How do you envisage the incorporation of the NECB 1995 in the Ontario Building Code? (see attached - identify preferred option or write down an alternative approach).

METHODS FOR INTRODUCING THE NATIONAL ENERGY CODE FOR BUILDINGS - 1995 TO THE ONTARIO BUILDING CODE

Current Ontario Building Code Reference to ASHRAE/IES 90.1-1989

2.1.1.11. ***Energy Efficiency.*** *Except for buildings of residential occupancy within the scope of Part 9, farm buildings and areas of buildings intended primarily for manufacturing or commercial or industrial processing, the energy efficiency of all buildings shall be designed to good engineering practice such as described in ASHRAE/IES 90.1-1989, "Energy Efficiency Design of New Buildings Except Lowrise Residential Buildings" and the "Guidelines for the Interpretation of ASHRAE/IES 90.1-1989" issued by the Ontario Buildings Branch of the Ministry of Housing.*

Proposal No. 1

2.1.1.11. ***Energy Efficiency.*** *Except for buildings of residential occupancy within the scope of Part 9, farm buildings and areas of buildings intended primarily for manufacturing or commercial or industrial processing, the energy efficiency of all buildings shall be designed to good engineering practice such as described in the National Energy Code for Buildings - 1995, or ASHRAE/IES 90.1-1989, "Energy Efficiency Design of New Buildings Except Lowrise Residential Buildings" and the "Guidelines for the Interpretation of ASHRAE/IES 90.1-1989" issued by the Ontario Buildings Branch of the Ministry of Housing.*

Proposal No. 2

2.1.1.11. ***Energy Efficiency.*** *Except for buildings of residential occupancy within the scope of Part 9, farm buildings and areas of buildings intended primarily for manufacturing or commercial or industrial processing, the energy efficiency of all buildings shall be designed to good engineering practice such as described in the National Energy Code for Buildings - 1995.*

Proposal No. 3

2.1.1.11. ***Energy Efficiency.*** *Except for buildings of residential occupancy within the scope of Part 9, farm buildings and areas of buildings intended primarily for manufacturing or commercial or industrial processing, the energy efficiency of all buildings shall be designed in accordance with the National Energy Code for Buildings - 1995.*

Building Official Information Package

IMPLICATIONS OF ADOPTING THE NATIONAL ENERGY CODE FOR HOUSING IN ONTARIO

9:00 a.m.
April 20, 1995

Boardroom 10B
10th Floor, 777 Bay Street
Ministry of Housing, Toronto

habitechnica

BACKGROUND

In 1995 the Canadian Commission on Building and Fire Codes will publish a model National Energy Code for Houses (NECH). If adopted by the provinces, the Code will require that all new houses meet or exceed minimum standards for energy efficiency. The NECH provides for each province or territory to have its own minimum standards, taking into account climate and regional energy and construction costs. In other words, the requirements for colder areas in the country and for houses heated with more expensive energy sources are more stringent.

The NECH will apply to all new buildings of residential occupancy that currently conform to the height and building area limits of Part 9 of the National Building Code; that is, buildings that are three storeys or less in height and that have a building area that does not exceeds 600 m^2 (6450 ft^2). The NECH does not apply to buildings where heating equipment is not installed, such as summer cottages.

The scope of the National Energy Code for Houses includes requirements for the building envelope, space heating and cooling equipment, mechanical ventilation, service water heating systems, lighting and electric power requirements.

There are three ways to comply with the requirements of the NECH: prescriptive compliance; trade-off compliance; and performance compliance. The prescriptive approach is like Part 9 of the Ontario Building Code (OBC), with simple to follow tables. The trade-off approach allows for more efficient equipment or insulation to be traded off against less efficient construction (for example, better windows, less wall insulation), and some minor calculations will be required. The trade-off approach, much like 9.38 Thermal Design in the OBC, requires documentation of equivalency. The NECH also offers a performance path that permits the most flexibility in meeting its requirements. Builders may choose whatever path is most cost effective for the way they build.

On the pages which follow, information is being provided to allow the building industry to become aware of the implications of adopting the 1995 National Energy Code for Housing in Ontario. After considering this information, it is hoped that stakeholders, like yourself, will take the time to participate in a forum to discuss your views.

IMPLICATIONS

The implications to the building industry have been broken down into several broad categories:

- ***First Costs Implications*** - the difference in costs associated with the adoption of the NECH in Ontario;
- ***Changes in Construction Practice*** - impacts on how you build your houses;
- ***Code Enforcement*** - plans, permits, inspections and the technical documentation which will be required; and
- ***Administration, Supervision, Co-ordination*** - the implications for paperwork, site supervision and dealing with suppliers of equipment and materials.

A number of other implications will be provided which relate to:

- **Life Cycle Costs** - the implications of the NECH on the total cost of the building across its expected life; and
- **Environmental Implications** - the greenhouse gas and other emission impacts of NECH adoption.

First Costs Implications

All first costs implications have been referenced to a two storey, 2,100 ft^2 dwelling located in Zone 1 (southern Ontario) where most of the housing starts in Ontario occur. Cost differences are generally greater in Zone 2 (northern Ontario).

The soon to be released study, *The Implications of Adopting the National Energy Code for Housing in Ontario,* reviews the cost implications for six house types in southern and northern Ontario

Building Envelope

There is practically no difference between OBC and NECH requirements for electrically heated homes, and homes with air source and ground source heat pumps. For electrically heated houses the NECH requires somewhat higher levels of attic insulation, while windows would likely need to be gas charged to meet the prescriptive requirements.

Homes heated with oil or propane would cost about $1,200 more in added insulation and better windows. Adoption of the NECH would have the greatest impact on this class of homes.

Natural gas heated homes would be practically the same under the OBC or the NECH. NECH provisions would likely require low-E windows for all gas heated houses.

Heating Systems

There is no change in the cost of heating systems since the same minimum efficiencies for appliances are required in the NECH as it references provincial energy efficiency acts. Setback thermostats, however, are required under the NECH, and the added cost of this requirement has been estimated to range between $100 and $250, depending on the type of equipment being controlled. As well, motorized dampers are required on fresh air intakes, and this can cost about $150 more.

Mechanical Ventilation

Heat recovery ventilation is required for all fuel types, except natural gas and ground source heat pumps, under the NECH in Zone 1. Compared with present OBC requirements, this means that all oil and propane heated homes will have to come equipped with HRVs, at an estimated premium of about $600.

Exterior Lighting

Exterior lighting controls are required under the NECH for every outdoor lighting fixture. It has been estimated that this could cost as much as $60 extra per outdoor lighting fixture.

Plumbing and Electrical

There are no significant impacts in terms of plumbing an electrical associated with adoption of the NECH.

Changes In Construction Practice

Building Envelope

Beginning with basements, there are no significant changes in how basements would be insulated under the NECH. All insulation values noted within the NECH are effective thermal resistances. These must be used instead of the nominal values presently used in the OBC. Builders and building officials will need to apply the NECH's *Appendix C, Method for Calculating the Thermal Resistance of Building Assemblies* to determine the necessary values. Further, the NECH requires the insulation be installed continuously, meaning that exterior fireplaces would have to be insulated. The airtightness of the dwelling must now be visibly attained, that is, an inspector must be able to see that all leaks and penetrations are sealed, otherwise he or she may require an airtightness test to be performed as a measure of compliance.

Heating Systems

Except for the provision of setback thermostats, practically speaking there are no impacts on heating system design or installation under the NECH.

Mechanical Ventilation

There are no significant impacts on mechanical ventilation system design or installation under the NECH, however, motorized dampers are required on any fresh air intakes to the building.

Plumbing and Electrical

There is no practical difference between the requirements of the OBC and the NECH with respect to plumbing and electrical work.

Life Cycle Costing Results

In general, the NECH would provide insignificant energy and life cycle cost savings for the vast majority of new home buyers in Ontario. Nonetheless, it would provide savings to new home purchasers whose buildings are heated with oil, propane and in most cases for those using heat pumps, both air and ground source. At the present time, for gas and electrically heated homes in Ontario there are no significant life cycle cost benefits from moving form the Ontario Building Code to the National Building Code for Housing in Ontario.

Environmental Implications

Adoption of the NECH provides limited environmental benefits for oil and propane-heated buildings. For the majority of new houses in Ontario moving to the NECH provides insignificant environmental benefits.

Code Enforcement

Plans/Documentation

Plans would generally have to be of higher quality permitting reviewers to check effective thermal resistance values. As well, documentation for insulation and window products may also be required. Additional costs for better plans and documentation will vary depending on how many houses are built using the same set of plans and documentation.

Permits

Due to a number of additional items to be enforced under the NECH compared with the OBC, it is likely that permit fees will increase somewhat. This depends on the level of Code enforcement presently provided in the community.

Inspections/Testing

Inspections should not be significantly different under the NECH requirements, however, they may take a little longer and cover more items. Depending on how the airtightness requirements of the NECH are interpreted, airtightness testing may be required in some municipalities, particularly when the trade-off or performance compliance paths are chosen. The cost of airtightness testing can range from $150 to $350.

Administration, Supervision, Co-Ordination

Paperwork/Documentation

There will probably be a slight increase in paperwork handling, particularly for the documentation of equipment efficiencies, window performance and insulation effectiveness data. This will further increase if the trade-off or performance compliance paths are chosen.

Quality Assurance

Site supervision may be required at a higher level than is currently provided in terms of air barrier installation. This may only be a temporary increase in time spent on site supervision, which may return to normal levels once trades have adjusted to the requirements.

Suppliers and Availability

The window industry may be slow to respond to improved window performance requirements, and the selection of products, along with competitive pricing, may dwindle during the transition period from present to NECH requirements.

Key Building Official Considerations

To put it all in perspective, the Code enforcement industry will need to determine which of the impacts apply to their business, and how much of a difference they will make. Some key considerations include:

- What are the implications for your municipality should Ontario reference the NECH within the OBC? Do you foresee any enforcement problems for your municipality?
- Additional paperwork and documentation may be required with the adoption of the NECH. Will this impose on undue burden on the enforcement industry?
- Are there aspects of the NECH that will be difficult to enforce?
- Tradeoff and Performance Compliance Paths:
    - What problems do you foresee (if any) in the adoption of a tradeoff and performance compliance path?
    - What level of documentation will your municipality likely require of the permit applicant that chooses the tradeoff or performance path?
    - What demonstration of competence (i.e. professional engineer, licensed architect, HRAI certification, etc..) would you recommend as necessary for a) tradeoff compliance or b) performance compliance? Could plans and designs be certified by trained architects, engineers or designers as a means of streamlining approvals? Would liability insurance be required of these individuals? Is liability insurance currently required for other aspects of the Code (e.g. Part 4 design)?
    - Could construction be certified by builders to streamline inspections?
- Could special energy code inspectors/plans examiners be used to check for NECH compliance in your municipality? Could the private sector play a role in this aspect of OBC enforcement?
- What is the nature of additional costs (if any) that may be imposed on the enforcement industry and on your municipality specifically if the NECH is adopted? Will the

adoption of the NECH impact permit fees?

- Will additional education and training be required for enforcement officials in your municipality? Will this present a financial burden to your municipality?
- Are there enforcement issues that need to be considered that relate to the windows (low-E and low-E argon) that may be required by the NECH? Labelling requirements?
- Should Ontario proceed with the adoption of the NECH?
- What should the next steps be?

These points, along with your own personal concerns, are the sorts of issues associated with the adoption of the NECH that you may wish to consider.

Your input to the process is important and valued. If you are unable to attend the forum, your views may be forwarded in writing to:

Habitechnica,
88 Prince Arthur Avenue, Suite 300
Toronto, Ontario, M5R 1B6
phone: (416) 961-3487, fax (416) 975-8819

Appendix VI

LIFE CYCLE COSTS SUMMARY

	OBC			NECH				NECHplus			
HOUSE ID	CAPITAL COSTS	PV OP. COSTS	LCC	CAPITAL COSTS	PV OP. COSTS	LCC	LCC DIFF	CAPITAL COSTS	PV OP. COSTS	LCC	LCC DIFF
TTLPMGF	$42,593	$7,422	$50,015	$42,911	$7,420	$50,331	($316)	$43,788	$6,737	$50,525	($510)
TTLPHGF	$43,870	$6,656	$50,526	$44,189	$6,652	$50,841	($315)	$45,064	$6,059	$51,123	($597)
TTSPMGF	$33,892	$5,777	$39,669	$34,140	$5,753	$39,893	($224)	$34,804	$5,232	$40,036	($367)
TTSPHGF	$35,169	$5,226	$40,395	$35,417	$5,205	$40,622	($227)	$36,080	$4,750	$40,830	($435)
TBSPMGF	$34,495	$6,555	$41,050	$34,669	$6,575	$41,244	($194)	$35,576	$5,898	$41,474	($424)
TBSPHGF	$35,772	$5,906	$41,678	$35,946	$5,923	$41,869	($191)	$36,852	$5,333	$42,185	($507)
TSDPMGF	$25,760	$5,488	$31,248	$25,875	$5,506	$31,381	($133)	$26,368	$5,015	$31,383	($135)
TSDPHGF	$27,037	$4,977	$32,014	$27,152	$4,992	$32,144	($130)	$27,645	$4,564	$32,209	($195)
TREPMGF	$23,462	$4,472	$27,934	$23,580	$4,500	$28,080	($146)	$24,045	$3,928	$27,973	($39)
TREPHGF	$24,740	$4,088	$28,828	$24,858	$4,113	$28,971	($143)	$25,322	$3,613	$28,935	($107)
TRIPMGF	$17,416	$3,350	$20,766	$17,561	$3,339	$20,900	($134)	$17,870	$2,986	$20,856	($90)
TRIPHGF	$18,693	$3,107	$21,800	$18,838	$3,097	$21,935	($135)	$19,148	$2,787	$21,935	($135)
STLPMGH	$44,156	$8,938	$53,094	$44,479	$7,843	$52,322	$772	$46,070	$6,658	$52,728	$366
STLPHGH	$45,433	$7,985	$53,418	$45,756	$7,977	$53,733	($315)	$47,347	$5,995	$53,342	$76
STSPMGH	$35,108	$6,869	$41,977	$35,480	$5,748	$41,228	$749	$36,702	$4,820	$41,522	$455
STSPHGH	$36,385	$6,188	$42,573	$36,757	$5,203	$41,960	$613	$37,979	$4,395	$42,374	$199
SBSPMGH	$35,396	$7,815	$43,211	$35,903	$7,115	$43,018	$193	$37,213	$5,989	$43,202	$9
SBSPHGH	$36,673	$7,013	$43,686	$37,180	$6,395	$43,575	$111	$38,490	$5,416	$43,906	($220)
SSDPMGH	$26,977	$6,580	$33,257	$27,054	$5,365	$32,419	$838	$27,967	$4,588	$32,555	$702
SSDPHGH	$27,955	$5,938	$33,893	$28,332	$4,944	$33,276	$617	$29,244	$4,194	$33,438	$455
SREPMGH	$24,210	$5,301	$29,511	$24,653	$4,122	$28,775	$736	$25,458	$3,357	$28,815	$696
SREPHGH	$25,487	$4,823	$30,310	$25,930	$3,786	$29,716	$594	$26,734	$3,118	$29,852	$458
SRIPMGH	$17,810	$4,004	$21,814	$18,444	$2,901	$21,345	$469	$18,930	$2,493	$21,423	$391
SRIPHGH	$19,087	$3,689	$22,776	$19,721	$2,718	$22,439	$337	$20,207	$2,361	$22,568	$208

CODES

T S	TL TS BS SD RE RI	P	MG HG
Toronto Sault Ste Marie	Two Storey Large Two Storey Small Bungalow Small Semi-Detached Row Exterior Row Interior	NECHplus	mid efficiency high efficiency