RESEARCH REPORT

BUILDING CANADA:

PHASE 1 FINAL REPORT

CMHC SCHL

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Building Canada

Phase 1 Final Report

EnerQuality Corporation

December 2003

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Executive Summary

Introduction

Building Canada has been loosely modelled on the existing Building America program. Building America operates by forming working partnerships among various stakeholders in the housing industry including designers, builders, engineers, manufacturers, and suppliers. Teams of experts re-engineer house designs to resolve builders' problems while improving occupant comfort, affordability, and energy efficiency.

The Building Canada process is based on building science and value engineering fundamentals. It takes a holistic and whole-house view, employing a systems approach. Designers, trades and sub-trades, draw valuable information from the interaction. Ideally, it brings to bear outside expertise to deal with specific issues. The relationship with the builder is placed at the centre of the process. Building Canada fundamentally implies a commitment to continuous improvement with testing, evaluation and re-testing of novel construction practices.

Building Canada is intended to draw out savings in labour and materials by improving construction efficiency and callbacks. Money saved (such as through reducing the number of framing members) is reinvested toward the cost of better-quality, high-performance components (such as energy- efficient windows). Builders and homebuyers benefit from the process.

Building Canada reduces builders' costs and secures builder support by addressing issues that matter to the builder: construction costs and callbacks. Efficiency and performance upgrades, including R-2000 certification, are funded by the savings. Building Canada could be leveraged against the R-2000 Program where specific R-2000 labels are desired but need not be inextricably tied to the R-2000 Program. Finally as production builders use processes that tend to become more disjointed than those of small builders, they represent the primary market for the integrating Building Canada process. Small builders are seen as a secondary market.

This report documents the testing of the Building Canada process with five different builders, two in Nova Scotia and three in Ontario. In order to preserve confidentiality, builders costs have not been specifically identified within the report; only aggregate cost data is shown for each upgrade or recommendation. Builders have not been specifically identified within the report.

The Builders

In the fall of 2001, the Building Canada team presented the principles underpinning Building Canada to a group of Nova Scotia builders. During on-site visits, it became clear that the Building Canada process could equally be applied to R-2000 builders as a means of encouraging R-2000 certification.

A pilot was proposed to test a zero cost R-2000 concept with two Nova Scotia builders, Builder A a production builder, and Builder B, a custom builder. The pilot project sets out to marry the lessons learned from the Building Canada initiative to the needs of the R-2000 Program as a means to overcome cost barriers and to increase the number of registrations of R-2000 homes in Nova Scotia.

The intensive nature of the process and the resources it implied, suggested that only those builders who could deliver a significant number of R-2000 starts or who could provide lessons that could be easily applied to a large number of similar builders would be considered for the pilot. The objectives for the Building Canada initiative were to identify means of the lowest cost R-2000 upgrade possible. Means of lowering construction costs, shortening construction time or lowering call-back costs were examined as ways to reduce the cost of upgrading to R-2000 construction.

Builder A, the production builder, accepted the recommendations of the Building Canada team. It committed to build a test house to the R-2000 standard with the Building Canada recommendations. Builder A reported that it's construction of its first Building Canada house to the R-2000 standard resulted in a total upgrade cost of $1400 with a savings from recommendations of $1500, for a net savings of $100 on the house.

Builder B, the custom builder had less success with the Building Canada process. As the process evolved it was clear, as originally conceived, that the Building Canada initiative was not suitable for this small custom builder as both his process was reasonably well integrated and savings were already largely identified with out Building Canada.

Two Ontario builders agreed to test the Building Canada process as a means of lowering construction costs, shortening construction time and lowering call-back costs which taken together would pay for the cost of upgrading to R-2000 construction.
The approach taken for these two builders focussed heavily on costs and drew on the experience of the subtrades. This represented a marked contrast to the Building Canada process carried out in Nova Scotia. These large Ontario production builders saw cost as the primary impediment to increased energy efficiency. As such, cost was carefully documented.

The approach used for Builder C and Builder D was more successful in many respects than for Builder A and B. The discussions with trades with the focus on costs and defects was engaging for the companies and appeared to foster commitment. By engaging subtrades directly, cost efficiencies could be discussed without threatening contracts that may be in place.

For Builder E, the construction review played a major part of the Building Canada process. Builder E constructed their first Building Canada house over a span of a few months. A number of decisions internal to the company took the construction of the first Building Canada house in directions not established at the outset of the project. Changing responsibilities for the project further exasperated the problem. The final Building Canada house was much more daring in attempting to demonstrate new construction technologies than had been initially planned by the Building Canada team. Builder E's project manager in some cases attempted to demonstrate new technologies that have only recently been mainstreamed within the residential market, pushing the limits of Building Canada objectives to optimize construction. As such, it's not clear to what extent Builder E will embrace the initiative as a whole. In future the team would recommend a much tighter control over the new technologies demonstrated.

Conclusions

Building America enjoys very significant US federal government funding and as such is an ambitious, far-reaching program. It is unclear whether a Building Canada initiative could enjoy a similar level of support. Building Canada, by necessity, will likely need to differ from its US counterpart. It is unclear whether the level of co-ordination and interaction enjoyed by Building America will ever be possible in the sparser Canadian market. Building Canada will need to evolve regionally, providing customized solutions to Canada's production builders.

The level of interest expressed by builders appears extraordinarily high. A number of builders who have completed the pilot phase have expressed interest in expanding the initiative to a larger number of homes. It is essential to note the importance of the trust relationship that develops between the builder and consulting team. The trust relationship should include senior company executives preferably up to the president's level. The Building Canada consulting team is often privy to private and confidential data including pricing and defect information that if made public could be detrimental to the builder's business. The trust relationship is also essential as the company's culture evolves as it embraces Building Canada.

Profitability and financial self-sufficiency is not contemplated for, at best, three years. The effort associated with the Building Canada initiative for any builder is diffuse and long lasting. The Building Canada team needs to be involved at the earliest possible point in the product development cycle. This implies that from concept to construction and evaluation, it is not unreasonable for the initiative to take 18 months for any one builder. It is expected that self-sufficiency and viability should be possible after two or three product cycles.

Building Canada is clearly not tailored for the small builder. In fact, it would appear that the benefits of Building Canada may be largely lost on builders constructing fewer than 100 homes per year.

Recommendations

The next steps for Building Canada would involve developing a fuller understanding of the market for Building Canada and expanding the initiative to other parts of the country. To this end a number of steps should be considered:

1. Develop a map of all production builders across Canada.
2. Identify 30 key builders interested in participating in Building Canada.
3. Establish and train regional Building Canada teams.
4. Deploy the Building Canada Teams.
5. Benchmark the performance of houses before and after Building Canada upgrades.

Résumé

Introduction

L’initiative Building Canada s’inspire quelque peu du programme Building America. Dans le cadre de ce dernier, des partenariats sont formés entre les différents intervenants du secteur de l’habitation, notamment les concepteurs, les constructeurs, les ingénieurs, les fabricants et les fournisseurs. Des équipes de spécialistes repensent les modèles de maisons afin de résoudre les problèmes des constructeurs tout en améliorant le confort des occupants, l’abordabilité du logement et la conservation de l’énergie.

Le projet Building Canada se fonde sur la science du bâtiment et sur les principes fondamentaux du génie. Adoptant une perspective holistique en matière d’habitation, il applique une démarche systémique. Les concepteurs et les ouvriers spécialisés et semi-spécialisés des métiers du bâtiment tirent de précieux renseignements de cette interaction. Idéalement, on fait appel à des spécialistes externes pour résoudre les problèmes particuliers. La relation avec le constructeur se place au centre du procédé. Le projet Building Canada implique essentiellement un engagement envers l’amélioration continue grâce à la mise à l’essai, à l’évaluation et à la remise à l’essai des nouvelles pratiques de construction.

Grâce à Building Canada, on compte réaliser des économies de main-d’oeuvre et de matériaux en améliorant l’efficacité des pratiques de construction et en réduisant les rappels. L’argent économisé (par exemple en réduisant le nombre d’éléments de structure) est réinvesti dans l’achat de composants à haut rendement de meilleure qualité (comme des fenêtres éconergétiques). Tant les constructeurs que les acheteurs bénéficient de l’opération. Building Canada réduit les coûts pour les constructeurs et gagne leur appui en répondant aux problèmes qui comptent pour eux : les coûts de construction et les rappels. Les améliorations touchant l’efficacité et le rendement, notamment celles qui sont apportées dans le cadre du programme d’homologation R-2000, sont financées grâce aux économies. Building Canada peut optimiser les avantages du Programme R-2000 pour les cas où des étiquettes R-2000 sont souhaitées, mais il n’est pas nécessaire que l’initiative soit intimement liée à ce programme. Enfin, comme les grandes entreprises de construction ont recours à des procédés plus fragmentés que les petits constructeurs, elles représentent le principal créneau d’adoption de la démarche intégrée de Building Canada. Les petits constructeurs sont considérés comme un marché secondaire.

Le présent rapport décrit l’essai de la méthode Building Canada auprès de cinq constructeurs différents, deux en Nouvelle-Écosse et trois en Ontario. Par souci de confidentialité, les dépenses des constructeurs n’ont pas été expressément consignées à l’intérieur du rapport. Seules les données regroupées sont présentées pour chaque amélioration ou recommandation. De plus, les constructeurs ne sont pas identifiés dans le rapport.

Les constructeurs

À l’automne 2001, l’équipe de Building Canada a présenté les principes sous-tendant le projet Building Canada à un groupe de constructeurs de la Nouvelle-Écosse. Au cours des visites de chantiers, il devenait évident que le procédé Building Canada pourrait également être appliqué aux constructeurs R-2000 comme moyen d’encourager ce type d’homologation.

On a donc proposé la mise sur pied d’un projet pilote visant à tester un concept R-2000 sans frais auprès de deux constructeurs de la Nouvelle-Écosse, le constructeur A - une

grosse entreprise de construction - et le constructeur B - un constructeur sur plans particuliers -. Le projet pilote visait à harmoniser les leçons tirées de l'initiative Building Canada aux besoins du programme R-2000 afin de lever les obstacles de coûts et d'accroître le nombre d'inscriptions de maisons R-2000 en Nouvelle-Écosse.

En raison de l'intensité de la démarche et des ressources impliquées, seuls les constructeurs pouvant exploiter un nombre important de chantiers R-2000 ou pouvant tirer des leçons facilement applicables à de nombreux collègues seraient considérés pour le projet pilote. L'initiative Building Canada avait pour objectif de relever les moyens par lesquels on peut mettre en pratique les améliorations R-2000 au coût le plus faible possible. Pour ce faire, on a examiné quels seraient les moyens de réduire les coûts de construction, de raccourcir la durée des travaux et de diminuer les frais relatifs aux rappels.

L'entrepreneur A, l'entreprise de construction à grande échelle, a accepté de mettre en pratique les recommandations de l'équipe de Building Canada. Il s'est engagé à construire une maison de démonstration conforme aux normes R-2000 en appliquant ces recommandations. Le constructeur a déclaré qu'au terme des travaux, le coût des améliorations à la norme R-2000 s'établissait à 1 400 $, tandis que les économies découlant des recommandations atteignaient 1 500 $, soit une économie nette de 100 $ sur la maison.

L'entrepreneur B, le petit constructeur sur plans particuliers, a connu moins de succès. À mesure que le chantier avançait, il est devenu clair, comme on l'avait pensé à l'origine, que l'initiative Building Canada convenait mal à ce type de constructeur, puisque ses pratiques étaient déjà raisonnablement bien intégrés et que les économies possibles étaient déjà réalisées sans l'application des recommandations de Building Canada.

Deux entrepreneurs de l'Ontario ont accepté de tester la démarche de Building Canada comme moyen d'abaisser le coût des travaux, d'en raccourcir la durée et d'abaisser les frais de rappel, l'ensemble de ces bénéfices compensant le coût de l'application des normes R-2000. La démarche adoptée par ces deux constructeurs portait principalement sur les coûts et tirait parti de l'expérience des corps de métier. Cette situation contrastait de manière marquée avec la démarche réalisée en Nouvelle-Écosse. Ces deux constructeurs à grande échelle de l'Ontario percevaient le coût comme le principal empêchement à l'application des mesures de conservation de l'énergie. Dans ce contexte, les coûts ont été soigneusement contrôlés.

La démarche appliquée par les constructeurs C et D s'est avérée plus fructueuse à de nombreux égards que celle des constructeurs A et B. Les discussions avec les corps de métier à propos des coûts et de la réduction des défauts éventuels ont eu pour effet d'impliquer les différentes parties à l'intérieur des entreprises. En faisant participer directement les corps de métier, on a pu discuter des gains d'efficience sans menacer les contrats en vigueur.

Pour le constructeur E, l'étape de l'examen a joué un rôle important dans le cadre de la démarche Building Canada. Ce constructeur a bâti sa première maison Building Canada en quelques mois seulement. Un certain nombre de décisions prises à l'interne dans l'entreprise ont donné à la construction de cette première maison des orientations non définies au début du projet. Le problème a été ensuite exacerbé par un changement de responsabilités. La maison construite au terme de l'expérience était beaucoup plus innovante dans la démonstration de nouvelles technologies de construction que ce qui avait été initialement prévu par l’équipe de Building Canada. Dans certains cas, le directeur de projet du constructeur E a tenté de démontrer de nouvelles technologies qui n'avaient été que récemment introduites sur le marché résidentiel, poussant ainsi les limites des objectifs de Building Canada afin d’optimiser la construction. Dans ce contexte, on ne sait pas trop dans quelle mesure le constructeur adoptera la démarche dans son ensemble. Pour l’avenir, l’équipe recommande qu’un contrôle plus serré soit exercé sur les nouvelles technologies démontrées.

Conclusions

Aux États-Unis, Building America bénéficie d’un financement très important de la part du gouvernement fédéral, ce qui en fait un programme ambitieux et de grande envergure. Au Canada, on ne sait pas si le programme Building Canada obtiendrait un soutien du même ordre. Par nécessité, Building Canada devra probablement différer de sa contrepartie américaine. On peut se demander si le degré de coordination et d’interaction que l’on retrouve dans Building America sera possible sur notre marché canadien clairsemé. Building Canada devra évoluer à l’échelle régionale, en offrant des solutions adaptées aux grandes entreprises de construction canadienne.

Le niveau d’intérêt exprimé par les constructeurs semble extraordinairement élevé. Certains, parmi ceux qui ont participé au projet pilote, désireraient étendre l’initiative à un nombre élevé de maisons. Il importe de souligner l’importance de la relation de confiance qui s’établit entre le constructeur et l’équipe de consultation. Pour que cette confiance existe, il faut obtenir l’appui des cadres supérieurs de l’entreprise, de préférence jusqu’au président. L’équipe de consultation de Building Canada a souvent accès à des données privées et confidentielles, notamment sur la tarification et les défauts, qui, si elles étaient rendues publiques, pourraient nuire aux affaires du constructeur. La relation de confiance est également essentielle, à mesure que la culture de l’entreprise évolue sous l’influence de la démarche de Building Canada.

On n’envisage pas la rentabilité et l’autosuffisance financière avant au moins trois ans. Les efforts que chacun des constructeurs doit déployer dans le cadre de l’initiative s’avèrent diffus et de longue durée. Il faut que l’équipe de Building Canada participe le plus tôt possible dans le cycle de la production Voilà pourquoi, depuis la conception jusqu’à l’exécution et à l’évaluation, on estime que 18 mois s’avèrent insuffisants pour n’importe quel constructeur. On pense plutôt que l’autosuffisance et la viabilité ne seraient possibles qu’après deux ou trois cycles de production.

Il est clair que Building Canada n’est pas adapté aux petits constructeurs. En fait, il semblerait que les avantages de la démarche seraient en grande partie inaccessibles pour les entrepreneurs construisant moins de 100 maisons par année.

Recommandations

Pour l’initiative Building Canada, les prochaines étapes consisteront à mieux comprendre le marché éventuel susceptible d’être intéressé par cette démarche et à élargir l’initiative à d’autres régions du pays. À cet effet, on envisagera l’application des mesures suivantes :

1. Dresser la liste de toutes les entreprises de construction de grande envergure d’un bout à l’autre du Canada.
2. Identifier 30 grands constructeurs intéressés par une participation à Building Canada.
3. Constituer et former des équipes régionales Building Canada.

4. Lancer les activités des équipes Building Canada
5. Faire une analyse comparative du rendement des maisons avant et après l'application des améliorations apportées dans le cadre de Building Canada.

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1.0 Background

The intent of the Building America program is to transform American home building practice. Building America was established in 1994-95 as a United States Department of Energy (DOE) program to increase the energy efficiency and affordability primarily of single-family homes. The program is funded by the DOE and housing industry partners. Building America operates by forming working partnerships among various stakeholders in the housing industry including designers, builders, engineers, manufacturers, and suppliers. Teams of experts re-engineer house designs to resolve builders' problems while improving occupant comfort, affordability, and energy efficiency.

A proposed Building Canada program has been modelled on the existing Building America program. Although Building Canada may seem similar to the R-2000 program (both result in better built, energy efficient homes), there are several important differences between the two initiatives. Unlike the R-2000 Program, Building Canada would achieve its goals through partnerships with the housing industry without trade name ownership encumbrances. It could be leveraged against the R-2000 Program where specific R-2000 labels are desired but need not be inextricably tied to the R-2000 Program. Building Canada would reduce builders' costs and secure builder support by addressing issues that matter to the builders themselves: construction costs and callbacks. Efficiency and performance upgrades, including R-2000, would be funded by the savings. Finally, in order to affect as many new homes as possible, Building Canada would be marketed to production home builders. As these builders use processes that tend to become more disjointed than those of small builders, they also represent a primary market for the integrating Building America process. Small builders are seen as a secondary market.

This report builds on the feasibility study of a Building Canada program fashioned after the successful Building America program. It applies the Building America process to a home to be constructed by Builder E.

Building America takes a systems engineering approach to home building. Its structure consists of teams with expertise in the key facets of homebuilding including design, engineering, manufacturing and supply of materials, construction, and finance who normally work apart from one another. The team, which views the house and its site as an integrated, interactive system of components, works with builders to develop and implement innovative construction processes and technologies. Builders and homebuyers benefit from the resulting savings in time, money, and energy consumption.

Through these integrated teams, the Building America program provides support and expertise that is otherwise unavailable to home builders. The program is aimed at production home builders in order to achieve the maximum results across the United States. House designs are completely re-engineered to utilize advanced products and to achieve maximum efficiency of framing components, mechanical systems, and materials use. A tradeoff system is applied whereby money saved on one feature (such as through reducing the number of framing members required) is reinvested toward the cost of other better-quality, high-performance components (such as energy- efficient windows). This is key to the success of the Building America program: better houses are constructed at little or no additional cost. The reworked house designs developed by the teams result in reduced construction time, less materials use and waste, fewer callbacks and warranty problems, and lower energy consumption. Builders and consumers save money, a market is provided for innovative products, and the houses are better built and more comfortable to live in than conventionally constructed homes. The Building America program is funded by both the U.S. government and private industry. The original DOE program provided U.S. $2.5 million per year divided among four teams.

Today, with the program in its eighth year, five Building America teams each receive U.S. $1.5 million from the DOE. These funds pay for technical support to builders who build at least two houses according to Building America principles.

The Building America program process is comprised of eight steps that are listed here and discussed in detail below:

1. *Marketing*
   Establishing a relationship with a builder.
2. *Research*
   Becoming familiar with a builder's operation.
3. *Re-engineering*
   Developing new house plans based on Building America principles.
4. *Refinement*
   Working with the builder and subtrades to develop the most workable design.
5. *Construction*
   Building demonstration homes based on re-engineered plans.
6. *Commissioning*
   Testing the demonstration homes' systems.
7. *Review and Revise*
   Reviewing the outcome and revising the approach to design.
8. *Commitment*
   Building additional homes according to re-engineered plans.

Potential difficulties in generating builder interest in a program such as Building America have been acknowledged. Home builders generally tend to be most interested in developing land as quickly as possible and financing developments that allow them to move land at the lowest cost. Joe Lstiburek suggested that builders are generally not interested in energy efficiency or building a better product, and many see home building as an annoyance and an aggravation. By reducing the number of product and system failures experienced though the conventional building process builders can readily appreciate the benefits of the program.

STEP 1:

To secure builder involvement in the program, the marketing focuses on value to the builder. Building a personal relationship is key: a one-to-one, face-to-face approach is most successful because it builds trust with the builder. The key to the successful introduction of a Building America type program has been to begin with one builder in each specific region of the U.S. Others follow as that builder is perceived to have an advantage. A five year relationship often needs to be established with each builder chosen. Builders have been selected based on callback and warranty problems, since the program reduces costs associated with these issues.

STEP 2:

Before re-engineering a house design, the Building America consultant becomes familiar with a builder's operation and methods. Walking through a typical example of the builder's work to review details is an important step. One day is devoted to working with the site superintendent, and one day with the trades (for example, meeting with framing subcontractors). Getting a sense of local competition is important. Reducing warranty callbacks to address builders' main concerns begins with identification of warranty issues. While current costs of callbacks are not always known: it is important to quantify these expenses because it will affect a builder's decision on whether or not to commit to recommendations. It has been a challenge to get builders who do not track callback costs to track them. In Chicago the Building America program has reduced problems associated with freezing pipes from approximately 100 annually to 1 or 2 annually for one builder. Cracking drywall was reduced from 85% to 35%, and problems with peeling exterior paint were almost eliminated. Town and Country Homes, a Building America builder, normally allocates $1000 per house to deal with warranty issues; the new budget allows $200 per house. Energy savings have been an added benefit: an energy star rating[1] was almost achieved.

STEP 3:
Beginning with one or two of the builder's house plans the mechanical system is re-engineered as follows:

- heat loss/heat gain calculations based on original and Building America specifications are performed.
- the mechanical system is rationalized (this reduces the number of runs and fittings).
- all mechanical specifications are revised.
- a duct layout with multiple returns is developed (the duct layout determines the framing layout; see Figure 1.2).
- the repair costs that might be necessitated on commissioning are built in.

Specific components of a re-engineered mechanical system include the following:

- simple supply system: single rectangular trunk, 7" oval vertical, 6" round horizontal.
- large (20" x 24") single return on main floor.
- bedroom grilles to bleed air from bedrooms (see Figure 1.1).
- one supply for every room; two for large rooms (e.g. mater bedroom).
- minimum 90% efficiency furnace, and power vent water heater.
- dedicated hard-connected outside air duct.
- to air handler (furnace); 40-80 cfm fresh air supply and 1-2 Pa pressurization resulting.

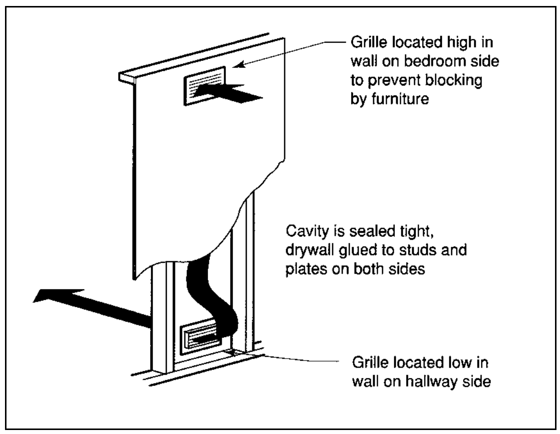


Figure 1.1: Supply & Return Grilles

[1] The U.S. Environmental Protection Agency defines an Energy Star Home as one that uses 30% less energy for heating, cooling, and water heating than a home built based on the Model Energy Code.

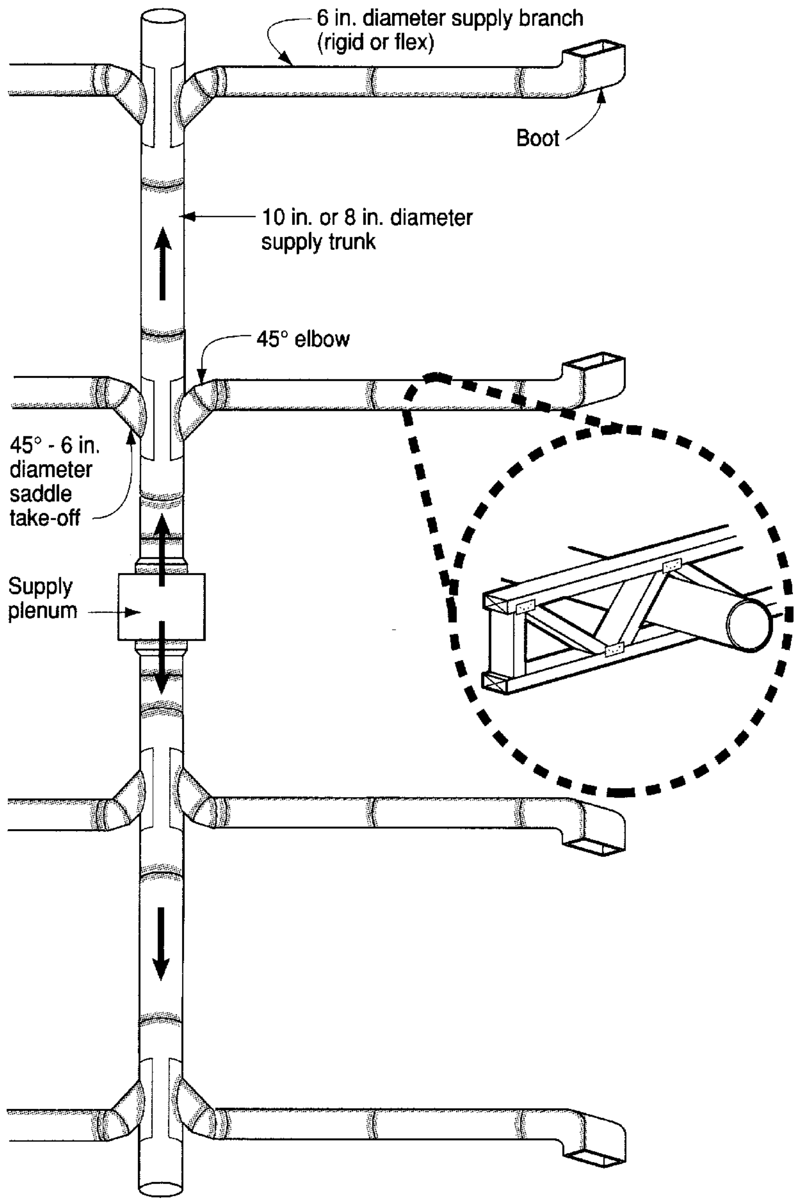


Figure 8.26
Supply Duct System

- Must be sized/designed on a case-by-case basis
- Supply duct system sized to fit within 14"-deep or 12"-deep open webbed floor trusses.
- Trunk ducts can be 10" diameter for 14"-deep floor trusses or 8" diameter for 12"-deep floor trusses depending on air flows and heat losses
- Branch supply ducts can be insulated flex
- Rounded ducts, 45° take-offs and 45° elbows reduce air flow resistance so ducts can be made smaller to fit in floor system

Figure 1.2 Supply Duct System

Framing is the next important element to be re-engineered. Building America applies advanced framing components and techniques to house plans. Some of the elements of a re-engineered framing plan include:

- slab-on-grade construction replacing basement;
- open web wood truss joists at 24" for easy installation of mechanicals (see inset Figure 1.2);
- ⅞" OSB subfloor;
- innovative bracing and anchorage in floor system;
- elimination of unnecessary framing members (such as cripple and jack studs for openings in non-loadbearing walls).
- 24" stud spacing.
- two-stud corners.
- stack (inline) framing.
- single top plates.
- drywall clips and floating corners at interior ceiling corners.
- steel T-bracing for walls.

Moisture control and thermal performance are also part of the re-engineering process. The new specifications usually includes the following components:

- a tight building envelope with well-installed air barriers.
- foil-faced extruded polystyrene insulating sheathing with shiplap joints replacing plywood sheathing and eliminating sheathing paper.
- elimination of the sheathing membrane[2].
- a move toward glued drywall.
- low-e, argon-filled glazing.
- gasketted electrical boxes (R5 vapour seal).
- R5 (1") exterior draining insulation[3].

Other house systems that might be optimized include:

- electrical,
- communications, and
- water.

STEP 4:
The Building America consultant, builder, and key tradespersons review the re-engineered working drawings to determine the most effective and efficient features to include in the demonstration house(s). Changes may be suggested, and a price is developed for both the Building America plans and the contractor's best alternative. The Building America consultant offers to take out any system that does not perform as expected.

Pricing the Mechanical System is handled in a particular way in order to achieve anticipated savings without expecting the builder or mechanical supplier to incur undue risk. The Building America consultant asks the builder what the re-engineered mechanical system would cost to install. This first price is invariably high because the builder is using new practices. After the first demonstration house is built, the consultant asks the mechanical supplier how the initial pricing related to the final product costs, and where areas of savings were found. Then the consultant requests a price that reflects the less expensive system. The mechanical supplier may split the savings with the builder; that is, both would share in the profits realized by the better system in subsequent houses. The builder has an opportunity to reinvest some or all of the savings in better performing systems.

Removing the pressure inherent in committing to new techniques is also helpful. This can be achieved by offering to replace unsuccessful

[2] sheathing membrane is required by the Ontario Building Code

[3] not permitted by Ontario Building Code

components with conventional products if builders are dissatisfied with the results.

STEP 5:
At this stage, arrangements are made for the builder to erect one or two homes according to the re-engineered and refined working drawings.

STEP 6:
The Building America program employs a design, test, redesign, retest process to resolve any problems in re-engineered homes. The following systems are commissioned:

- duct distribution system (air tightness).
- building envelope (air tightness).
- interaction of the mechanical system & envelope (pressurization).
- refrigerant (charge & flow).

Through the program, commissioning is made profitable for the mechanical installer by providing one hour's pay for a half-hour of commissioning work. This makes commissioning a profit centre rather than a cost burden. The costs of any changes or repairs required are absorbed by the Building America program.

STEP 7:
The results of demonstration home testing are discussed among Building America team members, builders, and contractors and are documented in case studies that enable builders to learn from each other.

The builder and the trades are involved in this review. The outcome of the commissioning process is reviewed. Successful changes are identified, and those that were not as successful are revised.

STEP 8:
With the commissioning of the demonstration houses completed and necessary changes made, the builder is ready to apply Building America principles to a housing development.

2.0 Building Canada Process Overview

In adopting Building America for the Canadian market, a number of significant changes have been made. To a large extent these have been driven by the much smaller Building Canada budget, which represents a small fraction of Building America's. At the same time, product improvement and cost efficiency remain the program's primary objectives.

Figure 2.1 identifies all of the steps in the proposed Building Canada process. The process builds on the effort and commitment to value engineering from specific builders. The process is holistic and whole-house, employing a systems approach. It involves designers, trades and sub-trades, drawing valuable information from the interaction. Ideally it brings to bear outside expertise to deal with specific issues. It places the relationship with the builder at the centre of the process. Finally, Building Canada fundamentally implies a commitment to continuous improvement from testing, evaluation and re-testing.

BUILDING CANADA PROCESS

STEPS

1. Build Canada Introductory Presentation - Builder Interest
2. Construction Review
3. Senior Management Presentation / Formation of Building Canada Builder Team
4. Service, Designers and Building Officials Workshop / Re-Design Sessions
5. Drawings and Details Finalized
6. Trades and Building Canada Team Session
7. Construction and Inspection
8. Test & Evaluation of Results
9. Builder Commitment

Figure 2.1

2.1 The Builders

This report details Building Canada's work with five builders. Two extended the process through to construction, while three are considering how best to respond to the Building Canada recommendations.

The names of all participants have not been reported to protect their identities given the often sensitive nature of the Building Canada investigation and its analysis. Three builders from Ontario participated (builders A, B and C) and two builders participated from Nova Scotia (builders D and E). This first phase experimented with different approaches to the application of the Building Canada principles. In some instances the process was intensive, over a finite number of days, while in other cases it extended over months as the builder considered various product and process improvements.

3.0 Nova Scotia: Builder A & Builder B

3.1 Introduction

In the fall of 2001, the EnerQuality Building Canada team presented the principles underpinning Building Canada to a group of Nova Scotia builders. During on-site visits, it became clear that the Building Canada process could equally be applied to R-2000 builders as a means of encouraging R-2000 certification.

A pilot was proposed to test a zero cost R-2000 concept with two Nova Scotia builders. The pilot project sets out to marry the lessons learned from the Building Canada initiative to the needs of the R-2000 Program as a means to overcome cost barriers and to increase the number of registrations of R-2000 homes in Nova Scotia.

The intensive nature of the process and the resources it implied, suggested that only builders who would be considered for the pilot were those who could deliver a significant number of R-2000 starts or who could provide lessons that could be easily applied to a large number of similar builders. The process extended over four days in contrast to how Building Canada was applied to other builders in this first phase. Two building companies were identified and engaged by Nova Scotia Home Builders Association (NSHBA) R-2000 Program to work with the project team to meet this challenge. These were Builder S and Builder B.

The objectives for the Building Canada initiative were to identify means of the lowest cost R-2000 upgrade possible. Means of lowering construction costs, shortening construction time or lowering call-back costs were examined as ways to reduce the cost of upgrading to R-2000 construction.

3.2 Methodology

Builders were recruited based on their public expression that cost was a significant barrier for building R-2000 homes. In all cases, builders suggested R-2000 would become a very real option for a significant number of starts if upgrade costs could be reduced to near zero. Builders co-ordinated a series of meetings for the consulting team with key trades involved in the construction of their buildings. Designers participated in individual meetings or in some cases in all of the meetings. Trades that participated included the carpentry, drywall/insulation, window, and mechanical trades. Discussion in the meetings attempted to identify:

- building defects and building performance issues specific to each trade;
- trade pricing structures;
- inefficiencies in design or construction; and
- specific measures which could improve margins for each trade.

General discussions were supplemented with specific recommendations for specific models which represented a significant number of current housing starts for each builder. Recommendations were intended to reduce the costs or improve performance. Where possible costs were quantified. These were reported on a per house basis. The discussion to follow summarizes the recommendations for each builder.

The project team was made up of Gord Cooke and Tex McLeod, with overall responsibility for the project assumed by Michael Lio. To maximize the transfer of expertise and understanding locally, the team was supplemented by the builders' R-2000 Design Evaluators - Terry Waters for Builder A and Dennis Naugler for Builder B. Given the short time frame to complete the project and the need to work around previous commitments, the project team traveled to Nova Scotia on March 4 and 5, 2002 to meet with Builder A.

A planning meeting was held on March 19 with Dennis Naugler to help set the stage for the Builder B visit which took place on March 27-28, 2002.

Even as the project team began reviewing plans in anticipation of the meetings in Halifax, it became evident that builders/design evaluators in Nova Scotia were having a difficult time meeting the R-2000 energy target in a cost effective manner.

On the surface, the climate in Halifax differs little from that of Toronto, but the HOT2000 target is substantially higher. Design evaluators typically needed additional efficiency measures for the same houses to meet the Nova Scotia target. Some homes simply could not meet the target - even with extraordinary measures. In altogether too many instances, builders simply would choose to install heat pumps as the only way to meet the R-2000 energy target. In some respects the R-2000 Program was running the risk of being seen as a heat pump program in Nova Scotia.

Upon arriving in Halifax, the team requested Natural Resources Canada (NRCan) to confirm that the climatic data currently used by HOT2000 was accurate. The project team proceeded to use the existing HOT2000 software, while NRCan investigated the possible anomaly.

3.3 Builder A

Builder A is a company in transition with new management, new designs and a new marketing program. The decision by NSHBA to invite them to participate in this project was both challenging and inspired: challenging because they are already a very lean builder; and inspired because done right – R-2000 is a perfect fit for the company. Nonetheless, R-2000 certification presents administrative, technical and construction challenges for the firm.

Builder A builds in a wide geographic area of the province and offers both standard house plans as well as the ability to custom build to a buyer's specific design. Their current efficiency standards are quite high and recently they have considered rationalizing them somewhat in an effort to be more competitive in some markets and offering a separate energy upgrade package. The company's current standard specifications are shown in Table 1.

TABLE 3.1
Builder A Standard House Specifications

Ceilings	R40
Walls	R20 – 2"x6" @16" spacing with 1.375" EPS II Foam
Foundation	R12 Batts in 2"x4", nothing under the slab
Windows	Standard Double Glazed
Heating	Electric baseboard
HRV	60% @ 0 C, 30 l/s
DHW	Electric

Builder A offers many variations in design. It also makes the purchaser responsible for heating choices other than electric baseboard. Other variations include the building's location, orientation, and foundation type. Taken together these variations make it extremely difficult for the sales staff to price and guarantee compliance to the R-2000 Standard at the time of sale. This problem is further compounded by the current version of HOT2000 that makes it very difficult for houses to meet the energy target in Nova Scotia (as compared to similar houses in seemingly similar weather zones in other parts of the country). Specifically, smaller houses, several of which are offered by Builder A, are often almost impossible to get to pass without the addition of a heat pump or other extraordinary and costly measures.

Given the wide trading area that Builder A builds in, ensuring local trades use appropriate materials, equipment and details that result in homes that comply with the R-2000 Standard can be difficult. In remote locations, on-site R-2000 inspections and air tests can also pose scheduling problems. To Builder a's credit, they have consistently met the airtightness requirements of the Program.

One of the Builder a's specific goals for this project was to come up with a standard specification for envelope and mechanical systems that would allow selected house models to meet the energy target in all geographical areas of Builder a's market, regardless of orientation. To that end the Builder A sales team identified seven new models that they felt were ideal candidates for their R-2000 offering. Six of these were chosen for evaluation for this project. In all cases, the Halifax weather data was found to be the most difficult geographical region to pass and all houses were rotated to determine the worst case orientation before envelope and mechanical systems were defined.

One of the builder's objectives was to move to a standard wall assembly – regardless of housing type – one that eliminated the need for exterior foam sheathing and that would utilize structural sheathing instead. This wall was seen as easier to build, more robust and would also create the possibility for a wall panel plant to be started, one that would construct wall components for all Builder A, including export (currently being considered by management). Another immediate short term objective for Builder A, was design guidance for details for the builder's Lifestyles home, planned as part of the NSHBA Parade of Homes in early May.

3.3.1 Weather File

NRCan's investigation confirmed that identical houses were considerably more difficult to pass in the Halifax climate zone than in most Ontario climate zones. The difference appeared to be in the lower average ground temperatures and differences in usable solar gains. NRCan did indicate that the weather data used in HOT 2000 was from averages between 1950 –1980 and that they were considering updating weather files in the near future. In the interim NRCan, sent a revised weather data file for Halifax that had a very dramatic impact on both the energy target and estimated consumption. As a result much of the early analysis done by the team was of little use.

The modified Halifax weather file was provided in late March by Anil Parekh of NRCan. After several attempts to get the file operational the Project Team finally got the file loaded and was then faced with a whole new reality. On one hand we now had a file that reportedly more accurately reflected Nova Scotia's recent long term weather parameters but the use of this new file had a significant affect on both the estimated annual energy consumption and the energy target. In all cases, the target was increased by at least 3% and the estimated consumption was reduced by at least 6% - this translated roughly into a 10% difference in performance. Table 2 details the variance between the old and new weather files.

TABLE 3.2 Energy Consumption Report: Nova Scotia House Files Percent differences between weather files						
House File	**ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION** MegaJoules (MJ)			**ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET** MegaJoules (MJ)		
	OLD WEATHER FILE	**NEW WEATHER FILE**	**Percent Change**	**OLD WEATHER FILE**	**NEW WEATHER FILE**	**Percent Change**
Two Storey	60000	55647	-7.26%	57354	59441	+3.64%
Two Storey - HP	44159	40776	-7.66%	57354	59441	+3.64%
Two Storey - Oil	77703	72329	-6.92%	78261	80870	+3.33%
Arizona	58897	54750	-7.04%	57465	59558	+3.64%
Arizona - HP	47014	43909	-6.60%	57465	59558	+3.64%
Arizona - Oil	80956	76013	-6.11%	78399	81015	+3.34%
Halifax	43315	39767	-8.19%	44085	45454	+3.11%
Halifax - HP	33759	31434	-6.89%	44085	45454	+3.11%
Halifax - Oil	54604	50227	-8.02%	61674	63386	+2.78%
Sheffield	49770	46534	-6.50%	53320	55189	+3.51%
Sheffield - HP	37633	35379	-5.99%	53320	55189	+3.51%
Sheffield - Oil	65527	61586	-6.01%	73219	75555	+3.19%
Trenton	47656	44326	-6.99%	48824	50449	+3.33%
Trenton - HP	36327	34056	-6.25%	48824	50449	+3.33%
Trenton - Oil	63135	59033	-6.50%	67598	69630	+3.01%
Rockwood	46725	43513	-6.87%	51541	53314	+3.44%
Rockwood - HP	35792	33622	-6.06%	51541	53314	+3.44%
Rockwood - Oil	62113	58147	-6.39%	70995	73210	+3.12%

This change has a dramatic affect on envelope requirements needed for R-2000 compliance. Table 3 below demonstrates typical alternatives for R-2000 compliance for a typical "Two Storey" Plan.

TABLE 3.3
Builder S Standard R-2000 Specification

	Old Weather File Alternative #1	Old Weather File Alternative #2	New Weather file
Ceilings	R50	R40	R40
Walls	R27.5, 2”x6” with 1.5” EPS II	R20, 2”x6” at 24” o.c., OSB sheathing	R20, 2x6 at 24” o.c., OSB sheathing
Foundation	R20 Batts in 2”x4” stand -off wall	R12 Batts in 2”x4” wall	R20 Batts in 2”x4” stand -off wall, 1 ½“ foam under slab
Windows	Low E, Argon, Insulated Spacers	Low E / Argon / Insulated spacers	Low E / Argon / Insulated spacers
Heating	Electric baseboard	Heat Pump	Electric baseboard
HRV	81% HRV	70% HRV	81% HRV
DHW	Electric	Electric	Electric

In short, the new weather file allows for the elimination of insulated sheathing in exterior walls and a reduction of ceiling insulation from R50 to R40. This could result in a savings of approximately $1000 in building materials alone. There is also very significant savings of switching from heat pump to electric baseboards. Other models showed savings of up to $1500 in materials. The new weather file allows for far more flexibility in choosing envelope and mechanical equipment options. With the old weather file it appeared the only consistent approach to meeting R-2000 was to include a heat pump or a solar DHW option which would commonly add $3000 to $4000 in costs to R-2000.

One important lesson gained from the analysis was to fully recognize the importance of sub-slab insulation for Halifax specifically and for Nova Scotia generally. In general the weather files indicate low ground temperatures. This results in higher basement heat losses through the slab. Placing 1.5” of EPS II foam under the slab had the same impact on energy consumption as placing 1.5” of EPS II over the exterior 2x6 walls. Of course, the slab area is about 40 – 50% less than that of the exterior walls. Substituting sub-slab insulation for exterior wall sheathing would result in significant material and labour savings.

The HOT 2000 runs on the six models selected by Builder A indicate the following specifications would consistently meet R-2000 energy requirements:

TABLE 3.4 Proposed Standard R-2000 Specifications	
Ceilings	R40 with a small raised heel
Walls	R20 – 2x6 @24" spacing with OSB Sheathing
Foundation	R20 Batts in 2x4 stand off wall or ICF walls, 1.5" EPS II under slab
Windows	Low E, Argon, Insulated Spacers
Heating	Electric baseboard
HRV	75% @ 0 C, 30 l/s
DHW	Electric

These specifications have a number of advantages:

- Warmer, drier / healthier, more livable basements
- Lower material and assembly costs for exterior walls using a standardized spec. (regardless of whether the house was R-2000 or not). Current practice includes metal braces for rigidity and four stud corners to provide a nailing base for siding which can now be adjusted. The OSB sheathing will have greater racking strength and provide a more consistent nailing base for the siding. The framing savings on the model due to the 24" spacings was estimated at $600.
- By adjusting / modularizing windows to fit the 24" stud spacing this would reduce the number of window headers and jack studs.
- Alternate heating options can now be offered by Builder A as upgrade options

3.3.2 Heating Guarantee

Regardless of the final heating system choice, the project team strongly urged Builder A to consider guaranteeing heating costs with or without the participation of Nova Scotia Power. In Ontario, the R-2000 Program provides a heating guarantee that incorporates a margin for normal variations. The Ontario Program has identified the financial risk as relatively small provided the heating guarantee's scope and application are specifically prescribed. The heating guarantee can also serve to attract media attention which could be used to market the Lifestyles home, Builder A and/or the R-2000 program.

3.3.3 Lifestyles Home Recommendations

In reviewing the Lifestyles Home, the consulting team provided Builder A with a number of recommendations as noted below:

Design

1. limit the home to 2 levels rather than 3 (entry and living room on the same level)
2. emphasize livability of the lower living area (ICF and in-floor heating) by changing the upstairs layout to 2 bedrooms and adding a third bedroom in the basement
3. simplify the roof design to eliminate the drop section, skylights in place of windows
4. expand consumer interest in the Lifestyle home through the use of the air quality features of the EnviroHome

Envelope

1. frame the outside walls and floors on 24” centers, utilizing 2 stud corners
2. sheath exterior walls in OSB and 1.5” Type II EPS foam board (although insulated sheathing is not recommended as part of Builder A’s new R-2000 offering insulated sheathing had already been donated for the Lifestyles Home by their generous supplier)
3. utilize an exterior air barrier, confirm air test prior to installing rigid foam at header
4. R50 in attic, use a modified raised heel using a small block
5. consider use of ICF foundation if costs are comparable
6. frame the basement kneewalls flush with the top of foundation wall
7. insulate under the concrete floor slab with type II foam
8. choose the low e, argon option on all windows (already ordered)

Mechanicals

Option A

1. consider time of use electrical heat using DHW and slab for storage
2. in-floor heating using a simplified layout / packaged distribution box
3. solar DHW connected to the hot water storage tank (assuming access to south)
4. direct vent propane fireplace to provide supplemental heat as required
5. pipe for propane BBQ on the back deck
6. install small electric baseboards in upstairs bedrooms
7. feature the new Venmar HRV / HEPA ventilation system

Option B

1. as above, except install a heat pump and ductwork in place of the time of use, baseboards and in-floor heating.

3.3.4 Cost Summary to Achieve R-2000 Compliance

Compared to Standard Specifications on model

A summary of anticipated costs for Builder A is shown in Table 5 below:

TABLE 3.5
Cost Implications of Optimized R-2000 Specifications

	Requirement	**Cost Impact**
Ceilings	R40	No change, other than a small raised heel truss **add $150**
Walls	R20 at 24" centres	Delete insulated sheathing, add OSB, wall framing to be at 24" o.c. **deduct $660 + labour savings**
Foundation	R20 + R6 under slab	R20 Batts in 2x4 stand off wall or ICF walls, 1.5" EPS II under slab **add $350 under slab + $300 R20 batts**
Windows	Low E Argon, Insulated spacers	**add $400**
Heating	Electric baseboard	Electric baseboard
HRV	75% @ 0 C, 30 l/s	compared to low end HRV installation, minus bath fans **add $250**
DHW	Electric – R10 Blanket	**add $50**
Air Tightness	1.5 ACH @ 50 pa.	No change, perhaps labour savings as details are cleaned up with new framing
Administration	File Management	use prescriptive "per model – worst case" design evaluation **add $600**
Total		**approximately $1440.**

TABLE 3.6
Energy and Operating Cost Implications of Optimized R-2000 Specifications

	Consumption (kWh)	Design Heat Loss	Yearly Estimated Electrical Costs
Standard	19074	9 kW	$ 1831
R-2000	14988	8 kW	$ 1438
Difference	4086	1 kW	$ 393

Given the simple construction elements identified in the above table, it is highly possible for Builder A to contemplate converting their entire production to R-2000. Upgrade costs are minimal and are largely associated with administration. The Estimated Annual Energy Costs in the table above were based on electrical costs of $0.096 / kWh including HST. The savings represent monthly savings of approximately $32 per month or more than $8000 over the 25-year term of a mortgage at 6% interest. The $32 monthly savings could be applied to the mortgage payments so that, in effect, a homebuyer could buy a house that is $3000 more expensive (in other words the monthly savings would pay for the increased cost for R-2000 construction). Alternatively, a consumer might see the $32 monthly savings in terms of other services they might be able to purchase, such as local monthly telephone services or cable upgrades.

3.3.5 Summary Builder A

Builder A accepted the recommendations of the Building Canada team. It committed to build a test house to the R-2000 standard with the Building Canada recommendations. Builder A reported that it’s construction of its first Building Canada house to the R-2000 standard resulted in a total upgrade cost of $1400 with a savings from recommendations of $1500, for a net savings of $100 on the house.

3.4 Builder B Construction

Over the past couple of years Builder B has reinvented his company from a small market custom builder into one of Halifax's premier custom builders. The company currently builds 15 - 20 high end executive homes a year. Builder B has made the corporate decision to build all their homes to the R-2000 standard. This pilot is expected to help the firm to strengthen and reinforce this decision through the optimization process.

Dennis Naugler, acted on behalf of the project team, to organize a series of meetings with management and trades. It became quite evident given Builder B's market niche that "zero cost" was neither a necessary nor a particularly realistic objective. What was needed though was a simplified way through the design process that would make it easier to achieve R-2000 compliance. From a marketing perspective, in the designer's words, their houses have lots of "wow" factor, which is why people choose Builder B. R-2000 supports Builder B's approach to marketing.

Seven of the last ten Builder B homes have installed air source heat pumps - generally because customers like the air conditioning inherent with the option. Customers also appreciate that the heat pump option is generally less expensive than a boiler with in-floor heating, which is the next most popular option. From an R-2000 perspective this means that virtually all houses with the heat pumps can easily meet the R-2000 target.

Mechanical trades, it appears size heat pumps according to the heat loss of the house. It is probably more cost effective to size the units based on air conditioning loads. In most cases, this would mean smaller, less expensive systems, smaller duct work and better summer dehumidification. The effects of a smaller system can be substantial. The decision to go with a heat pump often means that a 400 amp electrical service is required resulting in a panel upgrade of approximately $3500 - $5000 per house. Approximately 50% of Builder B houses require this upgrade. Other equipment and appliances can also affect the required service, for example a hot tub – an upgrade that normally costs $1,500 can often turn into $5,000 upgrade when the cost of electrical service is factored in.

3.4.1 Recommendations for Avoiding Electrical Service Size Upgrades

- Use HOT2000 and HRAI programs to ensure heating system is not oversized. The current method of using the electrician or the NS Power program may result in overly conservative sizing. In the case of the C and R Houses which were visited, both houses could have been serviced with an 18 KW electric furnace and 2.5 ton heat pump, eliminating the need for the service upgrade.
- Use a supplemental heat source such as a propane fireplace or propane water heater with in-floor heat in the basement to reduce peak electrical load demand. Alternatively, consider a solar hot water system to heat the DHW.
- Use some of the excess water heater capacity as a heat source for in-floor heating in the basement.
- Investigate load management control options that would manage appliance loads during peak periods.
- Consider "split heating systems". Simple in-floor heating systems in the basements run off the domestic water heater capacity (already included in the electrical load) and forced air heating (heat pump based) upstairs.

3.4.2 General Issues and Recommendations for Cost Effective R-2000 Houses

- With the old HOT2000 weather files, houses with oil-fired boilers or oil-fired furnaces were very, very difficult to get to meet the R-2000 energy target. Often extraordinary insulation levels were required. For example the R house required double wall construction with R36 insulation. The following recommendations would make oil fire R-2000 houses more cost effective.
- In the two houses the team investigated the window sizes and placement dominated the R-2000 design evaluation. More care and attention should be taken in considering orientation of the home and window sizes to optimize cost and performance. Often the customer meets with the window supplier to make final selections – neither of which fully appreciate the cost impact in meeting R-2000 requirements specific window changes might have. Windows are a big part of the image and styling of Builder B's homes, so training on optimizing passive solar utilization would be very useful for Builder B's designer, design evaluator and window supplier.
- Solar or heat pump based domestic water heaters would in many cases be a cost-effective way to meet energy budgets. These types of systems should cost less than $4000 and would help displace the impact of relatively low efficiency oil fired water heaters.
- Always use a high efficiency HRV and offset the additional cost by eliminating at least some of the supplemental bathroom fans. For larger bathrooms such as the ensuite use a direct ducted, quiet bath fan to supplement the HRV vent but do not connect it to the HRV duct.
- Given past record, plan for and continue to meet 1.0 ACH air tightness.

As seen by the chart below, the new weather files have a dramatic effect on R-2000 compliance. The net change is over 12% for both houses. In the case of the "R" house this allowed Builder B to revert back to a R27 wall on an oil house (2x6 with 1.5" banded polystyrene class II) and 1.5 ACH @ 50 Pa. air tightness target.

It appears that it will now be far more reasonable for Builder B to offer R-2000 houses to clients who prefer an oil heating option.

TABLE 3.7
Energy Consumption Comparison for Old and New HOT2000 Weather Files for Builder W House Files

House File	ESTIMATED ANNUAL SPACE + DHW ENERGY CONSUMPTION MegaJoules (MJ)			ANNUAL R-2000 SPACE + DHW ENERGY CONSUMPTION TARGET MegaJoules (MJ)		
	OLD[1]	**NEW**[2]	**Percent Change**	**OLD**	**NEW**	**Percent Change**
C Oil	130820	114518	-12.46 %	130971	136430	4.17%
Original	99462	90729	-8.78%	98529	102234	3.76%

[1] OLD – Previous HOT2000 weather file,
[2] NEW – Latest HOT2000 weather file

3.4.3 General Cost Savings Items

Framing Recommendations:

- Consider omitting strapping where a panel-type ceiling finish is installed on the underside of the floor system, particularly in garages.
- Consider omitting cross bracing where exterior walls are sheathed with OSB sheathing
- Review noted design issues that result in unexpected framing problems, expensive beams etc.
- Tall walls have resulted in very expensive framing options, these should be reviewed for possible savings, one option would be to substitute 2x8 framing for the timberstrand design currently in use.
- Roof designs should be reviewed with a view towards simplification and rationalization. Substituting attic trusses, for example, in the reviewed houses can be used to good advantage.

Air Sealing Recommendations:

- Although achieving the R-2000 airtightness levels has not been a problem for Builder B (typically around 1.0 ACH), it was recognized they were overly dependent on one particular individual in one particular company to achieve these results. Typically they have some problems with fireplace bump-outs, chimney chases and late installs of cabling and security system boxes. Standard details should be developed, sub contractors trained and ideas implemented on all houses. This would reduce reliance on the insulation contractor, spread the responsibility across more trades and provide a consistent approach.
- Sequencing of fireplace installations, tubs and bulkheads should be reviewed to improve air sealing and insulation.
- Pot lights are a big problem - Builder B often makes up their own boxes to go over top. There are typically 40 -50 in every house - 20 or more in insulated ceilings. Airtight fixtures should be sourced.
- The electrician doesn't like the plastic boxes and still uses polypans together with lots of caulking. Encourage a change in practice pricing benefits can result.
- Investigate the use of an exterior air barrier system at headers or alternatively a two component foam to replace sealed extruded polystyrene sheathing installed in the header space.

Heating, Ventilating and Air Conditioning Recommendations:

- Houses are not designed with ductwork in mind, especially not the large ducts required by the heat pump. There appears to be too many 4" diameter ducts used in many of the perimeter runs impeding proper airflow distribution.
- There seem to be many flush beams and joist direction changes that impair proper duct layout. The mechanical rooms appear too small. These should be reviewed.
- Budget fans have been installed in the HRV inlets in all bath rooms. Removing them would reduce installation costs and improve performance - keep one good fan in the ensuite.
- Consider limiting the heat pump size to 2.5 tons. This would reduce costs by over a $1000 and simplify wiring and duct sizing. As well, try to limit the heating system to 18 kW so that breaker is under 100 amps and therefore a 200 amp panel would be adequate. Additional energy efficiency measures can be added to reduce the required system size. This appears to be possible in the houses reviewed.

Plumbing:

- Limit the use of flush beams where possible to facilitate the routing of piping.
- Review the installation of plumbing in exterior walls. Consider use of plumbing walls.

- In-floor heating appears oversized and overly complicated with 7-8 zones per house reported. This adds approximately $1500 or more to a house that could easily be done effectively with a 4-5 zone system.

Windows:

- Technically good windows are used (low e, argon, insulated spacer). The only major recommendation is to attempt to anticipate the impact of window orientation/changes on energy consumption. Changes to windows often leaves design evaluators scrambling after the fact attempting to incorporate other compensating measures.

Designers:

- Sales/design staff should participate in an R-2000 sales course to better understand the R-2000 Program and the implications on design.

3.4.4 Summary Builder B

The individual recommendations listed have not been fully priced, Builder B did not have the data available to enable this pricing. Builder W has a very high standard specification and it is difficult to separate out specific items related to R-2000 from those that his clients would expect of a high quality builder. Rather the team felt the real goal was to help Builder W achieve R-2000 compliance without compromising design integrity or limiting the personal choices of individual clients that might otherwise raise the cost or complexity with respect to R-2000. For example, recommendations such as better training on passive solar utilization or standard details for air sealing “nuisance” areas will cost little but will help projects stay on budget and on schedule. As the process evolved it was clear that the Building Canada initiative was not suitable for this small custom builder.

4.0 Ontario: Builder C & Builder D

4.1 Introduction

Two Ontario builders agreed to test the Building Canada process as a means of lowering construction costs, shortening construction time and lowering call-back costs which taken together would pay for the cost of upgrading to R-2000 Construction.

In order to preserve confidentiality, builders costs have not been specifically identified within the report; only aggregate cost data is shown for each upgrade or recommendation.

The approach taken for these two builders focussed heavily on costs and drew on the experience of the subtrades. This represented a marked contrast to the Building Canada process carried out in Nova Scotia. These large Ontario production builders saw cost as the primary impediment to increased energy efficiency. As such, cost was carefully documented.

4.2 Methodology

The builders were recruited based on their public expression that cost was a significant barrier for building R-2000 homes. In all cases builders suggested R-2000 would become a very real option for a significant number of starts if upgrade costs could be reduced to near zero.

A series of meetings with key trades involved in the construction of the building was an important element of the Building Canada process for these builders. Designers participated in individual meetings or in some cases in all of the meetings. Trades that participated included: carpentry, drywall/insulation, window, and mechanical. Discussion in each meeting attempted to identify:

- building defects and building performance issues specific to each trade;
- trade pricing structures;
- inefficiencies in design or construction; and
- specific measures which could improve margins for each trade.

General discussions were supplemented with specific recommendations for specific models which represented a significant number of current housing starts for each builder. Recommendations were intended to reduce the costs or improve performance. Where possible costs were quantified. These were reported on a per house basis. The discussion to follow summarizes the recommendations for each builder.

4.3 Builder C

4.3.1 R-2000 Upgrade

A number of HOT2000 runs were completed to establish the most cost effective alternatives for meeting the R-2000 energy target.

The results of the HOT2000 simulations indicate that the worst case orientation is clearly when the house is facing east/west. A north/south orientation results in lower consumption of about 4% and would likely mean savings in the order of $500 - $750 from the worst case.

In all cases, low E , argon windows with insulated spacers that meet new R-2000 technical requirements for energy ratings (ER) are specified, although the house could pass its target in some cases with lower cost windows.

In all cases a domestic hot water heater that meets new requirements for energy factor (EF) ratings was also specified. This restricts dramatically the number of water heaters available and it is possible these higher EF heaters are not rentable. This will need to be confirmed with the gas service company.
It should be noted that little opportunity exists to vary construction as the simulated consumption is only marginally lower than the HOT2000 target.

It appears the specifications in the following table best meet the R-2000 requirements in light of Builder C's construction systems.

The "optional changes" represents a collection of alternatives from the "recommended R-2000 upgrade" that collectively would still meet the HOT2000 Energy Target.

TABLE 4.1

Building Component	Recommended R-2000 Upgrade	Optional Changes
Ceilings	R50 second floor, R40 first floor	R40 Ceilings throughout
Walls	2"x6" at 19.2" o.c., R20 batts, OSB sheathing, 2 stud corners, brick veneer	2"x6" at 24" o.c.
Foundation	R12 blanket wrap, full height	
Floors over garage	R28 insulation – either batt or foam	
Windows	Low E / Argon / Insulated spacers	
Furnace	94% AFUE	92% AFUE
HRV	75% at 0 oC/ 30 l/s Net sensible	81% HRV
DHW	Power or direct vent (0.62 EF)	

R-2000 Upgrade Costs	savings $4570
Low E, Argon + Insulated Spacer	$750
R40 Ceiling Insulation ($0.15/ft^2)	$200
Basement Blanket R12	$400
Air Sealing	$320
HRV	$1800
Furnace Efficiency	$350
Testing/Certification/Registration	$750

Testing/certification fees which include design evaluators fees, air tightness testing and field inspections normally range between $600 and $750 per house, on a one off basis. However, if we assume a 200 - 250 lot R-2000 site with construction spread over 3 years and assuming 12-15 house model types, total fees (not counting registration fees) should more likely approach $275 - $325 per house. Builder C could choose to do some of the testing and design work themselves which would undoubtedly further reduce costs. Reasonably testing/certification/registration fees should be approximately $750.00

4.3.2 Subtrade Optimization Meetings

Participants:

Carpentry Trade
Window Supplier
Mechanical Trade
Drywall Trade

General Comments
Subtrades were resistant to discussing any changes in practice, possible efficiencies or the effect on pricing. The general view of the discussion was they were being squeezed in an attempt to reduce prices on this and subsequent models. Repeated reassurances that they would not be asked to modify pricing in the near term made little difference. In many cases trades were less than co-operative in examining efficiencies. Subtrades that provide piecework pricing did not acknowledge the benefits of construction efficiencies and shortened construction time. While no credit would be possible on individual houses, trades failed to acknowledge that productivity improvements would result in increased overall profits despite constant per house margins.

4.3.3 Recommendations

The recommendations which follow fall into two general categories: those which have a direct impact on costs without affecting performance and those which substantially improve performance.

General	**savings $2420**
GD1. Defect Vigilance Communication (admin only)	$30
GD2. Chargeback Program savings (estimated)	($500)
GD2. Reward Management Project savings (margin only)	($100)
GD3. Integrate Marketing/Design/Constr. savings (estimated)	($2000)
GD4. Defects Database	$150

GD1. SIGNAL TO TRADES DEFECT VIGILANCE Piecework pricing seems to be a major impediment to promoting quality in housing construction. The current system puts the onus on builders to enforce quality through strong arm tactics which range from reminders and requests to back charges. The system forces builders to either invest in quality control systems or force defective product onto consumers.

It is recommended that Builder C identify low cost/no cost means of signalling to trades a new attitude with regard to defects. Quality awards, recognition certificates, and other promotional items may effectively draw attention to a new company-wide vigilance. Promotional initiatives should build on the experience of on-site safety promotional programs.

GD2. DEVELOP A DEFECT CHARGEBACK/REWARD PROGRAM The builder/trade relationship must change to reward reduced callbacks and promote better performance. Establish the cost of callbacks related to specific trades. Trades should be charged back for defects where clear responsibility can be established. Consider a reward management system that refunds part of the call-back budget to those trades responsible for the majority of callbacks where quality improvements and savings are clearly identified. End of year quality bonuses paid to subtrades will send a strong signal throughout the industry. Any reward management system should account for administration costs and the builder's margin.

GD3. INTEGRATE MARKETING/DESIGN/CONSTRUCTION: The marketing/design/construction process is not suitably integrated with the construction process. Marketing designs which form the fundamental basis of customer contracts are released prior to construction/design analysis. As a result, working drawings and construction "play catch-up" throughout the home building process. A piece meal approach develops to resolving problems adding substantially to the final cost of the finished product.

The designer reported a 4-6 week schedule to design an entire product line and suggested forcing the development of full construction drawings before marketing would almost double the time required to take a model to market. While this may be true, steps can be taken to better integrate the process.

Construction problems are typically reviewed as part of the first model with an as-built walk through. The current process results in defects that continue to appear in almost every house built. Refinements identified during the as-built walk through are often difficult if not impossible to implement.

A master set of mark-up drawings for every new model should be the normal result of the as-built walk through. Designers and major trades should be part of the walk through as well as marketing staff. Enhancing communication through feedback to designers and trades is a major recommendation within this item.

Inserting a short preliminary step that could be used to examine construction and savings opportunities is required. The step should include the design and marketing team and primary trades. It should give pre-qualified trades an opportunity to provide input to maximize construction savings and building performance. The one-on-one trade meetings should be conducted with each individual company to examine construction costs, construction efficiencies, construction time, building defects and building performance.

Designed-in defects are best solved by fundamentally addressing the design which caused them. Developing preliminary construction drawings which could allow a fuller construction review is recommended. Trades should individually be invited to help draw out efficiencies prior to the development of pricing drawings.

While marketing should not be driven by construction, design should consider the additional framing costs associated with:

- unnecessary floor areas (union framing rate:$3.10/sq.ft);
- more steeply pitched roofs (7/12:$0.2, 8/12:$0.25, 9/12:$0.3,10/12:$0.4, 12/12:$0.55); and
- wrap-around porches, etc...

Designers should be apprised of upcharge items and be part of the pre-pricing optimization meetings with bidding sub-trades.

GD4. CONTINUE TO IMPROVE DEFECT DATABASE
Continue to improve the Builder C defect tracking database. Defects should be tagged according to their system/component. Move towards standardized reporting of observation, cause, solution linked to the system/component tag. Database-generated reports on defect costs and chargebacks should be available for all defects. Review the Ontario New Home Warranty Program's Bulletin 19 defect tracking system for adoption.

Framing	**savings $1225.**
Lumber supply contract	$10,144
FD1. Floor Stiffness Complaints savings (admin only)	($25)
FD2. Floor Humps cost savings	($200)
FD3. Lumber Quality Program net savings (estimated)	($200)
FD4. Raised Heel Trusses	0
F1. Floor Framing savings	tbd
F2. Wall Framing savings	tbd
F3. Maintenance-Free Frieze Board	tbd
F4. Full Porch Columns (savings)	($800)

FD1. FLOOR STIFFNESS
The laundry room floor is often a source of complaints as being too stiff when compared to the rest of the house. Homeowners want consistent floor stiffness. Floor systems designed at near maximum spans are often considered too springy when compared to stiff floors (e.g. those under ceramics). Where spans are near maximum acceptable limits, consider approaches to stiffen the floor: frame in the next higher member depth; install additional bridging, blocking or strapping; glue and screw the subfloors; and/or, use of engineered systems.

FD 2. ELIMINATE FLOOR HUMPS
Floor humps are estimated to cost in excess of $200 per house with virtually every house reported as having a floor hump problem. The following should be considered:

- Eliminate beams that occur in the middle of a floor space.
- Where beams are necessary try to situate beams as near to partition walls as possible.
- Avoid changing joist direction in the middle of floor areas. Changes in floor joist direction should follow the same rules that govern beam placement.
- All steel in second floor framing should be eliminated, particularly steel posts.

- Where beams are necessary, avoid flush mounted tops. Try using 7" LVLs with 1/2" gap left below the subfloor. Monitor any improvement. An LVL option should be limited by this cost constraint.

FD 3. IMPROVE LUMBER QUALITY
The quality of lumber on Builder C sites has been reported to be below industry standards. As well, supplies are reported to be consistently short. Better lumber could add significantly to the overall costs of construction ($1000 to $3000 for this model). Nonetheless, options exist that should be considered:

- Institute a more formal quality assurance process for lumber for a limited duration and linked to specific lumber suppliers.
- Implement a return policy for substandard, subgrade lumber for all sites.
- Quantities should be monitored carefully with consistent under- supply patterns noted for remedial action.
- Devise and implement an on-site lumber storage policy for site superintendents.

FD 4. USE RAISED HEEL TRUSSES
Where possible raised heel trusses with a minimum 2"-3" heel should be used. The heel allows for better insulation of the top plate while also providing a nailing surface.

F1. EXAMINE FRAMING ALTERNATIVE
Some builders have shown alternative framing as an option to be cost effective in other regions. Differences in framing costs should be considered together with cost reduction from eliminating steel beams, steel columns, pads and nibs. Small differences in sheathing/cladding costs that account for the deeper floor members should also be considered. Assess the following recommendations:

Basement Floor Plan

1. Frame entire floor with 2" x 10" floor joists or wood engineered products as mentioned below.
2. Remove beam at rear of kitchen.
3. Add beam from 'front to back' under wall between breakfast and family room.
4. Change joist direction to 'side to side' under kitchen/breakfast area. Use 9 ½" wood engineered product for span
5. Adjust portion of steel beam to align under wall between dining room and kitchen. Add steel column as required.
6. Change joist direction to' front to back' under living room.
7. Construct a vertical key in the foundation wall with rebar to 'key in the garage slab to the foundation wall.

Ground Floor Plan

1. Frame entire floor with 2" x 10" floor joists.
2. Change joist direction to 'front to back' over living room.
3. Adjust framing around stairs for joists 'front to back'
4. Remove W150 x 22 steel beam at rear of garage. Use sprayed in place insulation in floors over garage.
5. Specify wood lintels of a consistent size, e.g. all 2" x 10" for time and labour savings.
6. Use lumber of lengths less than 16'-0" for cost savings

Framing Costs/Savings	tbd
Eliminate steel columns, pads and nibs	($850.00)
Price of additional sheathing and exterior finish	tbd

F2. WALL FRAMING: CONSIDER 2x6 +OSB WALLS WITH EXTERIOR HOUSEWRAP
Plastispan exterior insulated sheathing currently in use experiences considerable damage during construction. Repair costs have been estimated to exceed $60 per house. The sheathing provides limited resistance to wind during construction. OSB should reduce twisting and construction damage. Price and monitor call back budgets in a limited number of test houses. Housewrap permits the elimination of header wraps and would allow the use of thin interior vapour barriers. Exterior housewrap would also eliminate much of the current interior air sealing cost and effort (estimated savings $320). Recruit the local housewrap distributor to test the effectiveness of the new system. Consider:

- Framing costs (16" o.c. vs 24" o.c.)
- OSB costs
- Insulated sheathing savings
- Exterior house wrap
- Replace 6 mil with 2 mil poly
- Eliminate second floor header wrap
- Eliminate building paper
- Eliminate electrical box sealing
- Eliminate interior air sealing
- Air seal house wrap (at header, at flashing, at top plate)

F3. CONSIDER USING ALUMINUM CLAD OR STUCCO PRE-FINISHED FRIEZE BOARD
These maintenance-free items should be considered if the current practise results in significant defects or if the maintenance-free elements represent demand items.

F4. REPLACE HALF BRICK WITH FULL COLUMNS
At the front porch the half height brick columns can be replaced with a full column at a considerable savings.

Windows	**savings $490**
WD1. Low-e, argon, insulated spacer	(included in R-2000)
WD1. Condensation Callbacks savings (admin only)	($30.)
W1. Optimize Windows savings (estimated)	($260.)
W2. Other Window Recommendations	($200.)

Total Window Supply and Installation Price $5578

Window problems include: bowing, framing the wrong RSO (preventing use of clips and possible operation difficulties), theft, construction damage, condensation. More than 90% of window problems relate to construction damage.

WD1. USE LOW-E, ARGON WITH INSULATED SPACERS
Under the R-2000 Program this window type is the minimum required. The window glass will be warmer in winter and cooler in summer and should substantially improve thermal comfort. In winter these windows will be less prone to condensation problems. This important benefit has been priced at $30/house.

Window suppliers are offering the insulated "swiggle" spacer at no premium since it results in fewer leak complaints. Consider a move to the insulated spacer for all houses as it will reduce condensation call backs for all houses.

W1. OPTIMIZE WINDOW OPENINGS AND SIZES
Reducing the number of window openings in general saves approximately $16.00 per window based on installation costs and $13.50 based on framing costs.

Windows should be specified as standard available window sizes (widths: 20,24,28,32; heights: 28, 40,48, 52,60,64,70). Optimizing sizes reduces the cost of the window package by about $475. The slightly reduced window sizes on rear and side walls will not only reduce costs of windows but also reduce energy consumption to allow for R40 ceiling insulation or reverting back to a 92% efficient furnace.

Designers should design to the window supplier's window price sheets to optimize selections. Pre-qualified suppliers should optimize the window supply package as part of the window pricing. Had this optimization been carried out it would have identified the expensive side yard round-top window currently specified. The window is shown in marketing drawings and seems to provide limited aesthetic value given its treatment and location. The round-top window can be replaced with an equivalently sized square window at a savings of approximately $200. With glass sidelites, front door glass is not essential. Eliminating the glass in the front door saves approximately $60.

Consider:
- change master bedroom size to 96x48"
- change dining room size to 60x24"
- change rear ensuite to 2-24x40" (fixed and casement)
- change side window to 2-20x64"
- change breakfast to 20x60 (fixed)
- change side window on stair to standard rectangular without round top

W2. OTHER WINDOW RECOMMENDATIONS
Removing the soldier course over side yard windows will provide substantial savings. The clearance over the patio door has been a continued source of problems. A designed in solution is recommended.

- Remove soldier coursing over side yard windows ($150)
- Design in clearance of 1" over patio doors ($50)
- Drywall, Insulation, A/V Barriers savings $850

DD1. INSTALL R40 CEILING INSULAT'N ($0.15/FT^2) INCLUDED IN R-2000
DD1. Install Basement Blanket R12 (included in R-2000)
DD1. Provide R-2000 Air Sealing (included in R-2000)
DD2. Provide Drywall-Ready Homes savings (estimate) ($500)
D1. Redesign Floor Over Garage savings ($300)
D2. Examine use of cement board tbd
D3. Encourage use of plastic corner bead savings ($50)

DD1. INSTALL R40 CEILING INSULATION, R12 BASEMENT INSULATION, R-2000 AIR SEALING
Air sealing and added insulation will add to the cost of construction as identified in the R-2000 upgrade cost summary; however, the result will be more durable, more comfortable, quieter and less dusty houses. These intangible benefits have not been quantified but clearly add value to this recommendation.

DD2. NURTURE A REPUTATION FOR PROVIDING DRYWALL-READY BUILDINGS
Adverse indoor conditions have a significant effect on the incidence of drywall defects. Nurturing a reputation of providing buildings which are closed in with roofs in place and weather barriers installed should avoid upcharges drywall trades sometimes apply to

builders where the defect incidence is higher than normal. Drywall companies report upcharges of 10-15% on contracts where builders habitually fail to provide drywall-ready homes. While a total savings of approximately $1000 on bids is entirely possible, conservatively a $500 savings has been assumed from current practise.

Yearend callbacks on average involve 2 hours per house at a cost of approximately $100 for the subtrade. Help the trade to reduce this amount and demonstrate how this call-back reduction may translate into shared savings with the drywall trade.

D1. REDESIGN FLOOR OVER THE GARAGE
Paying strict attention to air and weather barrier detailing should reduce this cost and call-back incidence associated with this item.. Consider total cost implications including the garage foaming savings $300.

D2. EXAMINE THE USE OF DENSHIELD
For water exposed areas (bathtub surrounds) examine the use of denshield or a similar product which acts like cement board but cuts like plywood.

D3. ENCOURAGE THE USE OF PLASTIC CORNER BEAD
Shrinkage at cornerbeads on frame walls stud can cause unsightly cracking. Plastic corner bead can significantly reduce the time and effort of repairing drywall problems.

Mechanicals **savings $535**

Original Heat Loss:	66,200 BTU/hr
R-2000 Heat Loss:	42,000 BTU/hr

MD1	Reduce Comfort Callbacks (estimated)	($100)
M1.	HRV R-2000 Cost	(included in R-2000)
M2.	Eliminate fans/roof vents	($110)
M3.	Upgrade Furnace Efficiency	(included in R-2000)
M4.	Reduce furnace size (Design 66,200 vs 42000 BTUh)	($75)
M5.	Reduce air conditioner size (3 tons vs 2 tons)	tbd
M6.	Optimize Duct Layout	($250)

MD1 REDUCE COMFORT CALLBACKS
Substantial savings can be realized on comfort callbacks by adopting the R-2000 standard particularly as the program moves to full commissioning of mechanical systems. Only a modest savings is estimated for this item.

M1. HRV R-2000 COST
The 75% efficient HRV is necessary to meet the HOT2000 target. Most HRVs are either 60-70% or over 80%. The 75% unit reduces consumption by just over 350 kWh over a more common 70% unit and can be quite competitive with other units at lower efficiencies. Moving from the builder model HRV with an installed price of approximately $1200 - $1400 with efficiencies in the 60% range, will jump to $1600 - $1800 for 70% - 75% efficient units and another $300-$400 for units over 80%.

M2. ELIMINATE FANS/ROOF VENTS

There will be a small credit for elimination of bath fans (principal exhaust only). Bath fans on second floor should be retained to avoid having to run HRV ducts upstairs.

Remove principal fan	($65)
Remove 1 fans (incl $12 each ducting)	($45)

M3. UPGRADE FURNACE EFFICIENCY
The change to a 94% furnace from a 92% furnace is about $700 to the builder, however, some of this cost is related to the fact that the 94% furnace comes with two stage gas valve and likely with an electronically-commutated motor (ECM) (to be verified with the supplier). This of course provides other benefits beyond which HOT 2000 can model. If the furnace includes an ECM motor, the corresponding credit from HOT2000 would allow reverting back to R40 insulation in ceilings or perhaps a less expensive HRV. This would need to be confirmed when the final furnace is specified. So while the furnace may cost $700, it is possible the energy credit would save approximately $350 on other items.

M4. REDUCE FURNACE SIZE (Design 66,200 vs 42000 BTUh)
This saves only $75 to the builder, but should also create some small savings in duct sizes. It is important to ensure the there is enough fan capacity in the furnace blower to allow for proper air conditioning.

M5. REDUCE AIR CONDITIONER SIZE (3 tons vs 2 tons)
The R-2000 upgrade will allow a reduction in air conditioner size and likely furnace blower size. The precise cost impact of this item should be determined.

M6. OPTIMIZE DUCT LAYOUT
Mechanical system designs should not be left to the discretion of the mechanical trade. A mechanical system designer should be retained and the design should be reviewed and optimized by the trade. The pricing structure as noted below for the air distribution system should be considered by the designer in refining the design and should be queried by Builder C's staff:

- minimum number of runs chargeable:14
- floor holes cut- flat rate
- cold air returns - flat rate
- ductwork for fans - flat
- heating stack per stack per storey charge
- plenums in basement
- charge per run
- charge for furnace set-up
- cold air return jumpers

The following recommendations for the air distribution system should be considered:

1. line up 16" walls 12" joists in kitchen for services. tbd
2. replace 4" runs with 5" runs everywhere (same cost) tbd
3. move furnace to eliminate elbows ($25)
4. eliminate R2 return ($50)
5. eliminate runs 8,10,11,18,22 ($175)
6. heat internal washroom with 3-60W bulbs no charge

4.3.4 Summary

R-2000 UPGRADE COSTS	$4570
GENERAL SAVINGS	($2420)
FRAMING SAVINGS	($1225)
WINDOWS SAVINGS	($490)
DRYWALL SAVINGS	($850)
MECHANICAL SAVINGS	($535)
TOTAL SAVINGS	($5520)

The optimization of the Builder C model should allow for the savings to pay for the entire R-2000 upgrade and likely accrue significant additional savings for Builder C.

4.4 Builder D

4.4.1 R-2000 Upgrade

It appears as though the following specifications best meet R-2000 requirements:

TABLE 4.2		
Building Component	**Recommended R-2000 Upgrade**	**Optional Approach**
Ceilings	R50	
Walls	2"x6" at 24" o.c., R20 batts, OSB sheathing, 2 stud corners, brick veneer	2x4 at 16" o.c. with R12 batts, 1" XPS IV foam, brick veneer
Foundation	R12 blanket wrap, full height	
Floors over garage	R28 insulation – either batt or foam	
Windows	Low E / Argon / Insulated spacers	
Furnace	92% AFUE	
HRV	70% at 0 C/ 30 l/s Net sensible	81% HRV
DHW	Power or direct vent 0.62 EF	

The worst case orientations are clearly when the front of the house is facing either southwest or west. All other orientations would have annual energy consumption of 3 – 4% less and this would have quite an impact on required upgrades. From the worst orientation to the best orientation would likely not require R50 ceiling insulation and could revert back to the "Builders" Model HRV for a total savings of $600 - $800.

In all cases low E , argon windows with insulated spacers are required to meet the new the R-2000 technical requirements for energy rating (ER).

In all cases a DHW heater that meets new requirements for energy factor (EF) ratings has been included. This restricts dramatically the number of water heaters available and it is possible these higher EF heaters are not rentable.

As the simulated consumption is very slightly below the energy target for the building there is little room for any changes or variations in design or construction.

Normal fees for design evaluations, air tightness testing and field inspections currently range between $600 and $750 per house, on a one off basis. If we assume a 200 - 250 lot site over 3 years that has R-2000 standard, and assuming 12-15 house model types, total fees (not including registration fees) to be $275 - $325 per house. Of course, Builder D could choose to do some of the testing and evaluation work to reduce costs further. Certification/testing/registration fees are assumed to be about $750.00 per house.

The estimated annual energy savings at a natural gas price of $0.35 / cu.m. are $549.00 per year. This is a saving of $45.75 / month, which is equivalent to mortgage payments on $7,000 capital costs.

TABLE 4.3
Energy Consumption: R-2000 vs Standard Construction

	Consump-tion (M/year)	Natural Gas Costs / Year	Heat Loss (BTU/h)	Heat Gain (BTU/h)
Standard	157152	$1507	55,000	36,362
R-2000	97500	$ 951	43687	28,168

R-2000 Upgrade Costs	**$4450**
Low E, Argon + Insulated Spacer	$750
R50 Ceiling Insulation ($0.15/ft^2)	$400
Basement Blanket R12	$400
Air Sealing	$350
HRV	$1800
Testing/Certification/Registration	$750

4.4.2 Subtrade Optimization Meetings

Participants:

Site Superintendent
General Superintendent
Contract Manager
Designer
Air and Mechanical Trade
HVAC Designer
Carpenters
Drywall Trade
Window Supplier

General Comments
Subtrades were reassured that there was no intention to revisit pricing through these meetings. Although there was some resistant to discuss any changes in practice, trades were willing to discuss problems with the current process. As experienced in other meetings trades believe they are being pressured in an attempt to reduce prices. Trades were not co-operative in examining efficiencies. Subtrades that provide piecework pricing did not acknowledge the benefits of construction efficiencies on pricing. They continue to fail to acknowledge that productivity improvements could result in increased overall profits despite constant per house margins.

4.4.3 Recommendations

The recommendations which follow are organized in a fashion similar to those above. For completeness recommendations which also apply to Builder D have been repeated as necessary.

General Comments	**savings $2420**
GD1. Defect Vigilance Communication (admin only)	$30
GD2. Chargeback Program savings (estimated)	($500)
GD2. Reward Management Project savings (margin only)	($100)
GD3. Integrate Marketing/Design/Constr. savings (estimated)	($2000)
GD4. Defects Database	$150

GD1. SIGNAL TO TRADES DEFECT VIGILANCE

Defects result from design, products, materials, or installation. Some perceived defects are not defects at all but are viewed as such by homeowners. Strategies to deal with each type of defect range from better design integration, better quality assurance on products and materials and better control/reward of installation trades. Managing consumer expectation is a strategy often overlooked but which imposes a cost on the builder when left unattended. Condensation, for example, (on windows, behind poly in basements, etc...) is an example of a generally normal occurrence which is better dealt with by educating the homeowner on moisture sources, moisture control and ventilation system operation. In many cases, perceived defects are effectively dealt with by managing consumer expectation.

Piecework pricing seems to be a major impediment to promoting quality in housing construction. The current system puts the onus on builders to enforce quality through strong arm tactics which range from reminders and requests to back charges. The system forces builders to either invest in quality control systems or pass defective product onto consumers.

It is recommended that Builder D identify low cost/no cost means of signalling to trades a new attitude with regard to defects. Quality awards, recognition certificates, and other promotional items may effectively draw attention to a new company-wide vigilance. Promotional initiatives should build on the experience of on-site safety promotional programs.

Systemic approaches to managing consumer expectations through consumer education and perhaps third party training (using a consumer advocacy organization perhaps) should be investigated.

Problems experienced by this builder are not unique and are common among GTA builders. Siding problems, for instance, waviness, looseness, and buckling were among the first cited. Almost 40% of the installed siding is vinyl. Participants noted that a thicker product might reduce some of the problems experienced. Tolerance guidelines were also recommended. Each significant class of defects should be analysed with a cost and remedial budget established as party of an overall strategy. A charge back program should complement the defect strategy.

The cost of the siding problem was estimated to be about $175/house based on one in fifty houses requiring re-siding (cost: $3,000 to $4000).

Damaged kitchen countertops, vanities and tubs were cited as other problems for this builder as they are for all GTA builders. Suggested causes were trades using the countertops as workbenches, tubs used as walking surfaces or as garbage receptacles. Damage to countertops is estimated to cost the company about $50/house with tub repair costs at about $25/house. Shower pans damage is typically backcharged to the tile setter.

GD2. DEVELOP A DEFECT CHARGEBACK/REWARD PROGRAM
The builder/trade relationship must change to reward reduced callbacks and promote better performance. The cost of callbacks related to specific trades must be established. Trades should be charged back for defects where clear responsibility can be determined. Consider a reward management system that refunds part of the call-back budget to those trades responsible for the majority of callbacks where quality improvements and savings are clearly identified. End of year quality bonuses paid to subtrades will send a strong signal throughout the industry. Any reward management system should account for administration costs and the builder's margin.

GD3. INTEGRATE MARKETING/DESIGN/CONSTRUCTION:
The marketing/design/construction process is not suitably integrated with the construction process. Marketing designs which form the fundamental basis of customer contracts are released prior to construction/design analysis. As a result, working drawings and construction "play catch-up" throughout the home building process. A piece meal approach develops to resolving problems adding substantially to the final cost of the finished product.

Inserting a short preliminary step that could be used to examine construction and savings opportunities is required. The step should include the design and marketing team together with the primary trades. It should give pre-qualified trades an opportunity to provide input to maximize construction savings and building performance.

Construction problems identified in the first as-built walk through need to be communicated to design and marketing. The current process results in defects that continue to appear in almost every house built. Refinements identified during the as-built walk through are often difficult if not impossible to implement.

Designers and major trades should be part of the walk through as well as marketing staff. Enhancing communication through feedback to designers and trades is a major recommendation within this item. A master set of mark-up drawings for every new model should be the normal result of the as-built walk through.

Designed-in defects are best solved by fundamentally addressing the design which caused them. Developing preliminary construction drawings which could allow a fuller construction review is recommended. One-on-one trade meetings should be conducted with each individual company to examine construction costs, construction efficiencies, construction time, building defects and building performance. Trades should be individually invited to help draw out efficiencies prior to the development of pricing drawings.

While marketing should not be driven by construction, designer need to consider the additional framing costs associated with:

- unnecessary floor areas (union framing rate:$3.10/sq.ft);
- more steeply pitched roofs (7/12:$0.2, 8/12:$0.25, 9/12:$0.3,10/12:$0.4, 12/12:$0.55); and
- wrap-around porches.

Designers should be apprised of all upcharge items and all red line changes.

GD4. CONTINUE TO IMPROVE DEFECT DATABASE
Develop a comprehensive defect tracking database. Defects should be tagged according to their system/component. Standardized reporting of observation, cause, solution linked to the system/component is essential. Reports on defect costs and chargebacks for all defects

should be accessible from the database. Review the Ontario New Home Warranty Program's Bulletin 19 defect tracking system.

Framing	**savings $550.**
FD2. Floor Humps savings	($50.)
FD1. Lumber Quality Program net savings (estimated)	($500.)
FD3. Raised Heel Trusses	0
F1. Floor Framing savings	tbd
F2. Wall Framing savings	tbd

Floor squeaks were reported as among the most prevalent framing problems. With floor bounce and floor humps not nearly as important. Only 1 in 50 houses require significant work on floor humps while floor bounce is typically dealt with by managing consumer expectation through what typically is a ten minute discussion.

Floor squeaks impose a $500/house cost with floor humps at about $50/house and bounce estimated at $10/house. Engineered lumber typically adds $1500/house.

FD 1. IMPROVE LUMBER QUALITY

Lumber quality was also cited as problematic. The company accepts that 25-30% of the lumber it is provided is substandard. While Builder D has determined that for the company kiln-dried lumber is not cost effective. It is recommended that measures should be taken to: verify grade of lumber supplied, verify appropriate quantity supplied and assess quality.

- Institute a more formal quality assurance process for lumber for a limited duration and linked to specific lumber suppliers.
- Trades should be encouraged to report substandard product to site supers. Site supers should be encouraged to take a more proactive quality assurance role.
- Implement a return policy for substandard, subgrade lumber for all sites.
- Devise and implement an on-site lumber storage policy for site superintendents.

Improving lumber quality together with minor additional measures will reduce the incidence of floor squeaks.

FD 2. ELIMINATE FLOOR HUMPS

Floor humps are designed-in problems that required designed-in solutions. Recommendations Builder D should consider include:

- Eliminate beams that occur in the middle of a floor space.
- Where beams are necessary try to situate beams as near to partition walls as possible.
- Avoid changing joist direction in the middle of floor areas. Changes in floor joist direction should follow the same rules that govern beam placement.
- All steel in second floor framing should be eliminated, particularly steel posts.
- Where beams are necessary, avoid flush mounted tops. Try using 7" LVLs with 1/2" gap left to subfloor. Monitor any improvement. An LVL option should be limited by this cost constraint.
- Examine carefully where reverse window interior wells are required. These often result in mini humps in floors above rear windows. Examine the use of window wells in the few instances where windows would otherwise extend below grade.

FD 3. USE RAISED HEEL TRUSSES

Where possible raised heel trusses with a minimum 2"-3" heel should be used. The heel allows for better insulation of the top plate while also providing a nailing surface.

F1. EXAMINE FRAMING ALTERNATIVES
Builder D should consider the following framing recommendations:

Basement Floor Plan

1. Frame entire floor with 2" x 10" floor joists or wood engineered products as mentioned below.
2. Change joist directions to' front to back' under dining room and foyer.
3. Eliminate W200 x 27 steel beams running from 'front to back'.
4. Add one steel beam from 'side to side' under the wall between dining room and foyer, from the edge of foundation wall to a column at the corner of the stair
5. Add one steel beam under the wall between the stairs and the living room.
6. Change floor joist direction to 'front to back' in both the living room and hallway.
7. All floor joists to run 'front to back'
8. Remove the steel beam under the great room floor and clear span with 9 ½" wood engineered floor joists.
9. If the steel beam is to be used, relocate the column to align with the wall between the breakfast and the great room. Have the bottom of the floor joists aligned with the bottom of the steel beam.
10. Construct a vertical key in the foundation wall with rebar to key in the garage slab to the foundation wall.

Ground Floor Plan

1. Move the wall between the kitchen and dining room to align with the steel beam below.
2. Change joist directions to' front to back' in dining room (to stair) and foyer.
3. Add a flush wood beam from 'side to side' from wall between dining room and foyer, to a column at the corner of the stair.
4. Add a wood lintel from the column at foyer to wall between stair and living room.
5. Change joist direction to 'front to back' in living room.
6. Change steel beam in garage to 'side to side'.
7. Add beam from 'front to back'at outside edge of bedroom 2.
8. Change joist direction from front to back under bedroom 2, laundry and walk-in closet. Use sprayed in place insulation in floors over garage.
9. Remove beam in great room and clear span with 9 ½" wood engineered floor joists.
10. If steel beam is to be used, run from 'side to side'. Beam to align with kitchen/breakfast wall. Adjust walls on second floor to align on top of beam. Have the bottom of the floor joists aligned with the bottom of the steel beam (beam to be less than 9 ½" deep)

Framing Costs/Savings	tbd
Eliminate steel columns, pads and nibs	($850.00)
Price of additional sheathing and exterior finish	tbd

F2. WALL FRAMING: CONSIDER 2x6 +OSB WALLS WITH EXTERIOR HOUSEWRAP
Housewrap permits the elimination of header wraps and would allow the use of thin interior vapour barriers. Exterior housewrap would also eliminate much of the current interior air sealing cost and effort. Recruit the local housewrap distributor to test the effectiveness and cost of the new system. Consider:

- Framing costs (16" oc vs 24" oc)
- OSB costs
- Insulated sheathing savings
- Exterior house wrap
- Replace 6 mil with 2 mil poly
- Eliminate second floor header wrap
- Eliminate building paper
- Eliminate electrical box sealing
- Eliminate interior air sealing
- Air seal house wrap (at header, at flashing, at top plate)

Windows **savings $230.**

WD1. Low-e, argon, insulated spacer (included in R-2000)
WD1. Condensation Callbacks savings (admin only) ($30.)
W1. Optimize Windows savings (estimated) ($200.)

Window operation problems (binding windows) has been reported as the second largest problem after floor squeaks. Accounting for a 3/8”-1/2” gap below the window has eliminated most of the problem.

Damaged or scratched glass adds approximately, $100-200 per house. The problem is sometimes backcharged to bricklayers.

WD1. USE LOW-E, ARGON WITH INSULATED SPACERS
Low E, argon, insulated spacer upgrade was approximately 20% on a one off basis but could be as low as $500 if it is made a standard. There appeared to be little interest in changing window sizes or types to lower costs although experience indicates substantial savings are possible.

Low E / argon windows would reduce peak cooling loads by just over 0.5 tons to 2.5 tons rather than 3 tons. This is an important consideration since a 3 ton system usually requires a furnace with a higher airflow range – that is the Low E will support the change to a smaller furnace.

The insulated spacers was a no charge upgrade. Builder D should ask for them as a standard to reduce window condensation callbacks. Builder D reported 10% of homeowners expressed concerns about window condensation.

Under the R-2000 Program this window type is the minimum required. The window glass will be warmer in winter and cooler in summer and should substantially improve thermal comfort. In winter these windows will be less prone to condensation problems. This important benefit has not been priced.

W1. OPTIMIZE WINDOW OPENINGS AND SIZES
Designers should design to the United window price sheets to optimize selections. Prequalified window suppliers should optimize the window supply package as part of the window pricing. Had this optimization been carried out it would have identified more cost effective options.

Drywall, Insulation, A/V Barriers savings $850

DD1. Install R50 Ceiling Insulatn ($0.15/$ft^2$) (included in R-2000)
DD1. Install Basement Blanket R12 (included in R-2000)
DD1. Provide R-2000 Air Sealing (included in R-2000)
DD2. Provide Drywall-Ready Homes savings (estimate) ($500)
D1. Redesign Floor Over Garage savings ($300)
D3. Encourage use of plastic corner bead savings ($50)

DD1. INSTALL R40 CEILING INSULATION, R12 BASEMENT INSULATION, R-2000 AIR SEALING
Air sealing and added insulation will add to the cost of construction as identified in the R-2000 upgrade cost summary, however, the result will be more durable, more comfortable, quieter and less dusty houses. These intangible benefits have not been quantified but clearly add value to this recommendation.

Insulation stops should be installed where required in attics.

DD2. NURTURE A REPUTATION FOR PROVIDING DRYWALL-READY BUILDINGS
Adverse indoor conditions have a significant effect on the incidence of drywall defects. Nurturing a reputation of providing buildings which are closed in with roofs in place and weather barriers installed should avoid upcharges drywall trades sometimes apply to builders where the defect incidence is higher than normal. Drywall companies report upcharges of 10-15% on contracts where builders habitually fail to provide drywall-ready homes. While a total savings of approximately $1000 on bids is entirely possible, conservatively a $500 savings has been assumed from current practise.

Yearend callbacks on average involve 2 hours per house at a cost of approximately $100. for the subtrade. Helping the trade to reduce this amount and demonstrating this call-back reduction may translate into shared savings with the drywall trade.

D1. REDESIGN FLOOR OVER THE GARAGE
Paying strict attention to air and weather barrier detailing should reduce this cost and call-back incidence associated with this item. Consider total cost implications including the garage foaming savings $350. Communicate the need for a continuous header wrap with no discontinuities.

D3. ENCOURAGE THE USE OF PLASTIC CORNER BEAD
Shrinkage at cornerbeads on 2x6 walls stud can cause unsightly cracking. While the issue is related to lumber quality, plastic corner bead can significantly reduce the time and effort of repairing these drywall problems.

Mechanicals	**savings $535**
MD1 Reduce Comfort Callbacks (estimated)	($100)
M1. HRV R-2000 Cost	(included in R-2000)
M2. Eliminate fans/roof vents	($110)
M3. Reduce furnace size (80,000 vs 60000 BTUh)	($75)
M4. Reduce air conditioner size (3 tons vs 2 tons)	($400)
M5. Optimize Duct Layout	($200)

MD1 REDUCE COMFORT CALLBACKS
Substantial savings may be possible on comfort callbacks associated with R-2000 construction particularly as the program moves to full commissioning of mechanical systems. Conservatively only a modest savings is assumed for this item.

Proper design should limit noise from return air, particularly in houses without basements where the furnace is located on top of a return. Furnaces located under returns should have ducts run out and back with a jumper. Ductwork insulation should be used where called for.

M1. HRV R-2000 COST
The 81% efficient HRV is a premium of $300 - $400 over a standard HRV. So the first jump for the builder is a “builders’ model” HRV with an installed price of approximately $1200 - $1400 with efficiencies in the 60% range. The price will jump to $1600 - $1800 for an “R-2000” model at 70% - 75% efficient units and another $300-$400 for units over 80%. There will be a small credit for elimination of bath fans – consider keeping bath fans on second floor to avoid having to run HRV ducts upstairs. This would reduce the cost of the HRV installation by approximately $200 - $300. Net incremental cost for installing a 70% HRV would be $1400 - $1500.

M2. ELIMINATE FANS/ROOF VENTS
There will be a small credit for elimination of bath fans (principal exhaust only). Bath fans on second floor should be retained to avoid having to run HRV ducts upstairs.

Remove principal fan	($65)
Remove 1 fans (incl $12 each ducting)	($45)

M3. REDUCE FURNACE SIZE
We can reduce furnace from 80,000 BTU to 60,000 BTU. This saves only $75 to the builder, but should also create some small savings in duct sizes.

M4. REDUCE AIR CONDITIONER SIZE (3 tons vs 2 tons)
The R-2000 upgrade will allow a reduction in air conditioner size and likely furnace blower size. The precise cost impact of this item should be determined.

M5. OPTIMIZE DUCT LAYOUT
In general, the air flow and therefore the ability to effectively cool the second floor is questioned. The need for the numerous return air inlets on second floor is questioned. The return air to bonus room likely has little air moving through it. Effective heating of the room is also questioned. Air flow through the model home as currently designed should be measured to verify air is moving at a desirable rate.

Heating layout is now done when the design is 100% complete. The mechanical layout needs to be done sooner. The rule as reported that "you have 30 minutes to do mechanical layout" needs to be reconsidered. Complete the mechanical design before pricing drawings are complete. Mechanical system designs should not be left to the discretion of the mechanical trade. A mechanical system designer should be retained and the design should be reviewed and optimized by the trade. The pricing structure as noted below for the air distribution system should be considered by the designer in refining the design and should be queried by Builder C's staff:

- minimum number of runs chargeable:14
- floor holes cut- flat rate
- cold air returns - flat rate
- ductwork for fans - flat
- heating stack per stack per storey charge
- plenums in basement
- charge per run
- charge for furnace set-up
- cold air return jumpers
- no more than five elbows per run

Eliminate the supply and return duct to the garage ceiling plenum. In addition three other supply runs can be eliminated. This represents a total savings of approximately $150 - $250.

4.4.4 Cost Summary

R-2000 UPGRADE COSTS	$4450
GENERAL SAVINGS	($2420)
FRAMING SAVINGS	($550)
WINDOWS SAVINGS	($230)
DRYWALL SAVINGS	($850)
MECHANICAL SAVINGS	($885)
TOTAL SAVINGS	($4935)

The optimization of the Builder D model should allow for the savings to pay for the entire R-2000 upgrade and likely accrue significant additional savings to Builder D.

4.5 Summary

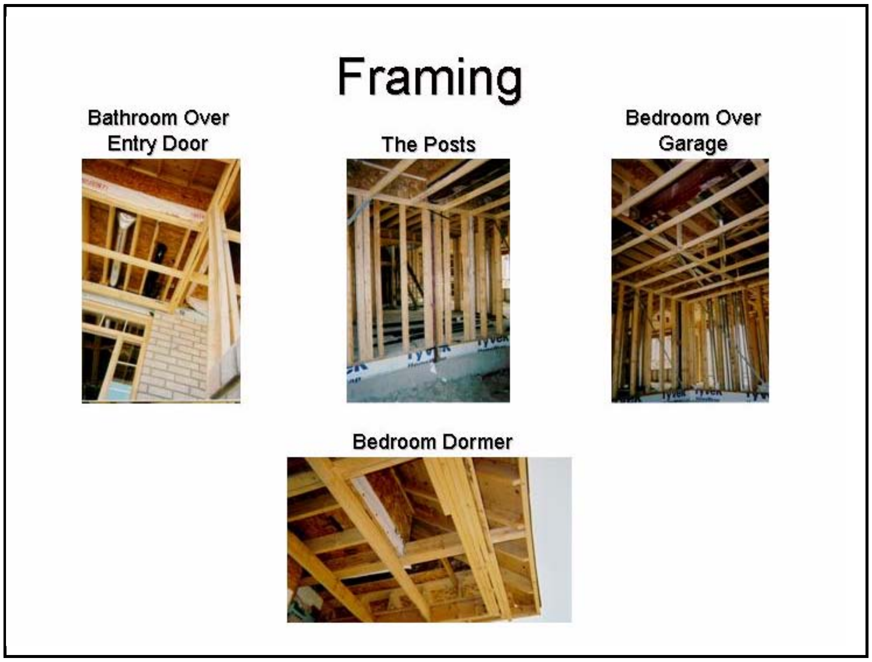
The approach used for Builder C and Builder D was more successful in many respects than for Builder A and B. The discussions with trades with the focus on costs and defects was engaging for the companies and appeared to foster commitment. By engaging subtrades directly, cost efficiencies could be discussed without threatening contracts that may be in place.

5.0 Ontario: Builder E

For Builder E, the construction review played a major part of the Building Canada process. Builder E committed early to the construction of a Building Canada house. This chapter documents the entire Building Canada process for Builder E.

5.1 Review of Existing Construction

The following figures depict specific construction problems identified by the Building Canada team for the 56/53 model for a house to be constructed in Toronto. Each figure includes commentary that details and describes the noted aspect of construction. The commentary also describes the trades and whether or not the designer needs to be involved.



Bathroom Over Entry Door
A bathroom is located directly above the front door with services in the ceiling/floor area. This is one of 3 dormers located on this side of the house, all with their floors projecting out over the porch area. Given the potential for cold floors, pipe freezing caused by air leakage and poor insulation, it is recommended that this area be reviewed to determine a more efficient method to achieve effective detailing. The current method is difficult to build, hard to insulate and impossible to air seal effectively.

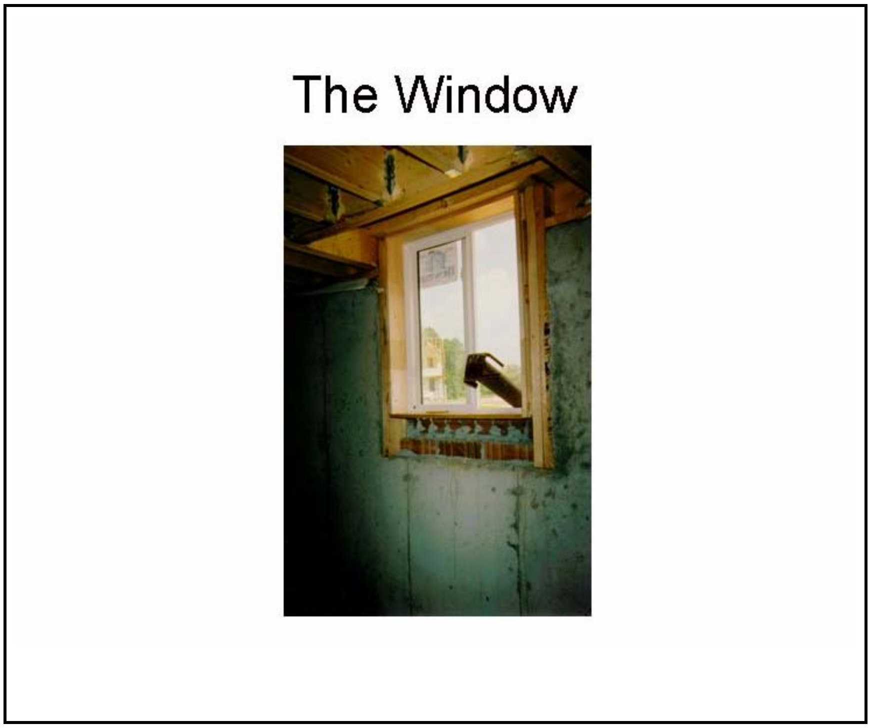
Posts
Within 3 feet of the steel post (note the header area) supporting the steel beam there is a second, wooden, post that takes the load of a beam truss. The drawings should be reviewed to examine whether these members could be located over each other or eliminated altogether through a redesigned roof / floor system. Where the posts are located in the wall separating the garage from the living space the insulation is compromised. The garage walls would benefit from insulated sheathing to overcome the heat losses at the posts and at the ducts.

Bedroom Over the Garage
This photo is taken from the garage looking up at the underside of the bedroom floor. The expectation is that this floor will suffer from comfort problems due to the difficulty in insulating and establishing an effective air barrier. A leaky air barrier may allow car exhaust from the garage to enter the living space. Steel beams create thermal bridges. The duct runs should be taped and their location reviewed. The manner in which the duct runs travel from the basement to the second floor will result in a section of wall being poorly insulated with considerable heat lost to the garage area.

Bedroom Dormer
This dormer floor viewed from under the porch is directly to the right of the bedroom. The floor area should be insulated and air barriered from one side of the building to the other rather than as 3 separate floor areas.

Design: truss manufacturer, designer

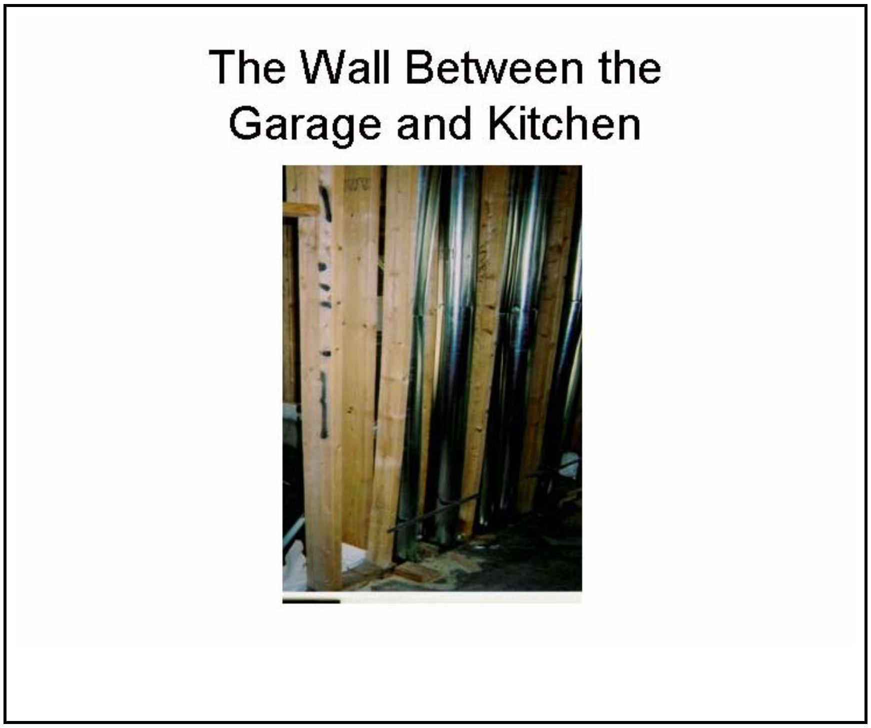
Construction Trades: framers, insulator, plumber and heating contractor



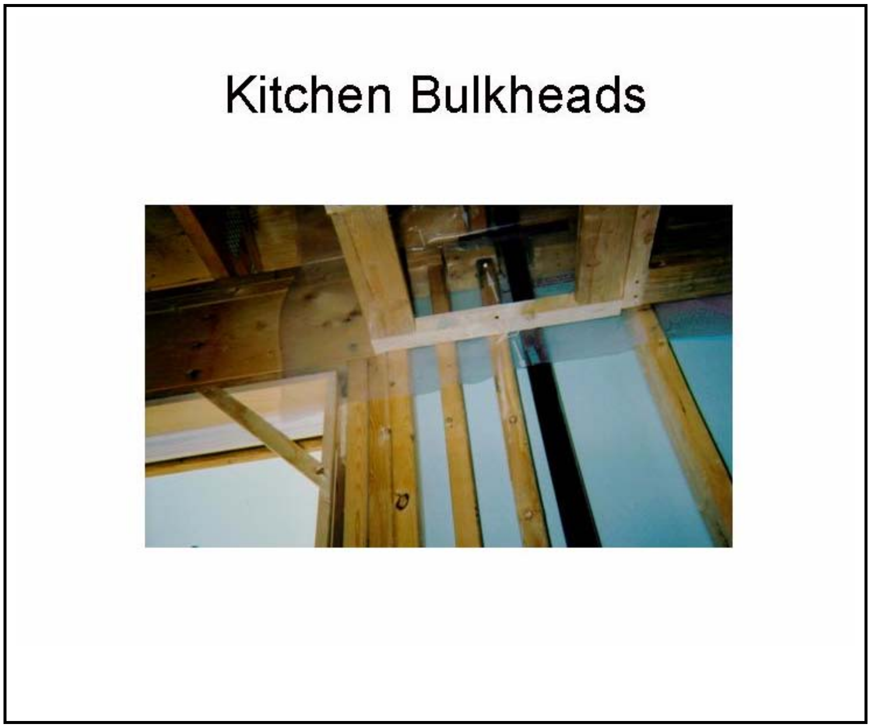
The Window
This window could have been installed below the joists, simplifying the joist layout and eliminating the need for the doubling of the joists and bricking below the window.

Design: designer

Construction Trades: foundation contractor, framers



Wall Between the Garage and Kitchen
This shows the recess for the refrigerator which allows it to be pushed into the wall and the multiple duct runs to the second floor. There are issues of air / gas tightness on this wall as well as compromised insulation with the numerous duct runs.
It might be possible to review the plan to see if these runs could be relocated within the building envelope, perhaps in a chase. An open web joist might allow for simpler duct layouts. It is also worth noting that improved windows might allow for simpler and fewer layouts. This is made possible by improving window performance with low e and argon, eliminating the need to locate outlets under windows.



Kitchen Bulkheads
This area will be very difficult to air seal. It would be far more effective to install the polyethylene and drywall in this area before building the bulkhead. After the boarding the drywaller could use steel studs to construct the bulkhead. Furthermore, this is another place where double jack studs are used where typically one would be sufficient. It is very difficult to air seal around plumbing pipes where a reciprocating saw removes chunks of plate rather than using hole saws. It should be noted that the location of the air barrier should be confirmed. A well detailed exterior air barrier would make some of these concerns redundant.

Design: designer

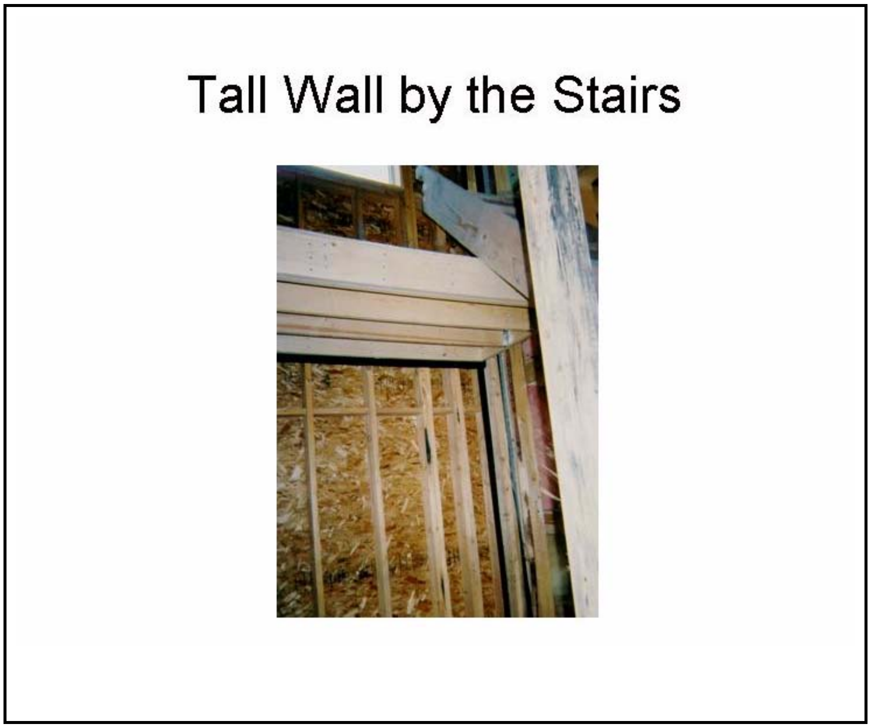
Construction Trades: framers, drywallers, insulators

Underside of First Floor
As seen in the photo there is a mix of engineered bridging and conventional cross bridging with strapping. If this ceiling were to be drywalled, the parallel finish could act as structural strapping. The engineered bridging is not extended as far as the ceramic tile, as was the intention and the mix of bridging types leads to a confused job site and possible discontinuities with respect to deflection. It would be worth reviewing the specifications to determine if a floor on 16” centers with 3/4“ sheathing and a consistent bridging would not be more appropriate.

Underside of Second Floor
This floor area should be reviewed to determine whether a more rational structure is possible. Currently, a beam is supporting another beam. The joists on one side are on 12" centers and 16" centers on the other. Rationalizing framing and eliminating point loads where possible can result in more uniform deflection and often better performing and less expensive floor systems.

Design: designer

Construction Trades: framers



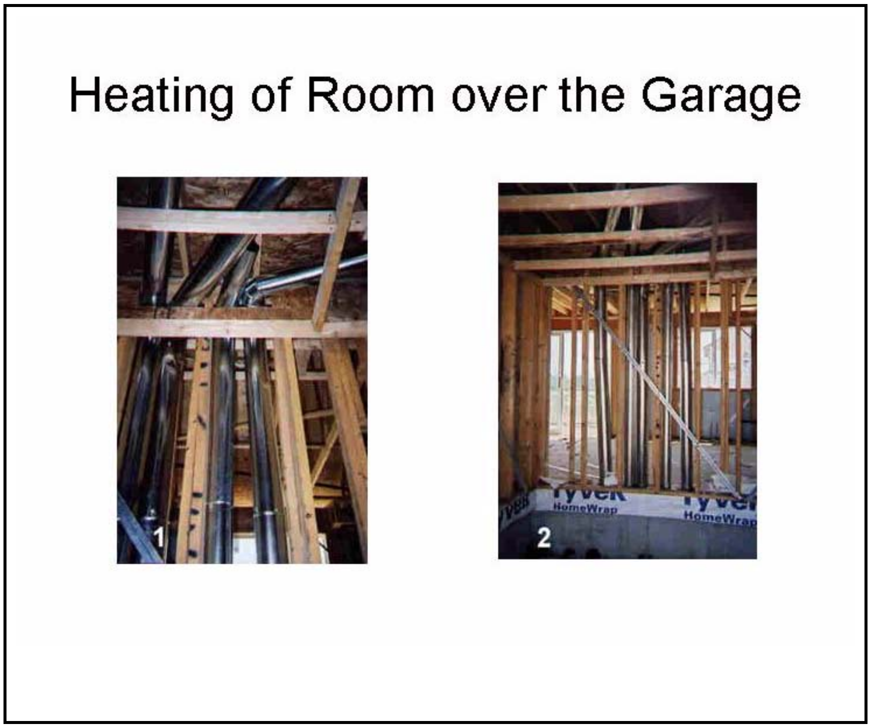
Tall Wall by the Stairs
This is a location where an engineered / stamped detail could be used. There is very little loading on the wall, the trusses span the opening, and the need for a lintel over the window should be reviewed. In addition, the requirement for 2 x 6s on 12" should be also be reviewed as the landing may provide sufficient lateral stiffening. 12" centres mean extra lumber and additional work to cut all the insulation.

Dormer
This is a hand cut, raftered dormer where the rafters take all the roof load of the gable. There is no need to put a lintel over the dormer openings or the jack studs.

Roof Girder Truss
This roof design necessitates placing posts to transfer roof loads. There are two alternate roof designs that should be considered: the use of 1 1/2 storey trusses placed on the 8 foot rear wall with a 4' differential built in so they sit on a four foot knee wall in front incorporating two different roof pitches. Dormers could be pre built and placed by crane at the same time as the trusses speeding up installation. Another alternative would be to investigate an attic truss for use over the garage which then would eliminate the need for a steel beam.

Design: designer, truss manufacturer

Construction Trades: framers



Heating of Room over Garage
The heating and cooling of the room over the garage includes not only the duct runs to the rooms but also a warm air supply and return air duct to the cavity under the floor. These two runs can be eliminated by a more efficient design of the floor assembly. The duct runs to the room should be rationalized and relocated into the floor joist assembly. All joints should be well sealed or taped. Other ideas for this area include:

- Consider using oval duct for these runs to increase R-Value under the duct.
- Oval Duct, or rectangular duct in the vertical runs to these rooms could also eliminate the double wall currently employed. This would dramatically improve air tightness while reducing material costs.
- Employ a "trunk" system design: one large duct up to wall split into 2 or 3 runs at the floor level. This may reduce labour and framing allowances.

Design: designer

Construction Trades: heating contractor

Heating System Overall
It appears as though the heating system is very tight to the design load of the house. A key issue is the awkward location of the furnace. The location necessitates long lengths of main trunk ducts and many large fittings. Relocation and redesign of the heating system for this model should be investigated to reduce costs.

40% cooling – lost opportunity

Design: designer

Construction Trades: heating contractor

Air Sealing
There are many opportunities for rethinking air sealing / vapour barrier details. Rationalizing details produces great improvements in air tightness, resulting in better comfort and better building performance. This can be realized at lower or no additional cost. Some suggested details include:

- In the double wall between the garage and the house the air barrier is compromised by the duct and plumbing runs despite the double thickness of the wall. The framing should be redesigned to improve air sealing details.
- Rethinking or eliminating the header wrap, as it provides little to no value on this site. It is not properly maintained during the construction process, nor is it continuous throughout.
- Redesigning the framing of the front dormers.
- Creating a common specification for air barrier details in bulkheads and behind tubs and showers.

Ventilation – fan recycler

Design: designer

Construction Trades: framers, insulators

Brick Ledge
These photos show before and after brick installation (using the house next door as the before). It would have been possible to have completed the wall above the brick ledge in wood frame, increasing the insulation levels in that area. If there is insulating blanket used in this area it is questionable if it would extend 2' below the finished grade. Given the use of foundation drainage layer, foundation coat and insulating blanket investigating an alternate approach to provide capital cost savings without compromising performance should be considered. Header Wrap, Consider – knee wall. Peculiar to grading on site. Insulate 2' below grade. Cost will be far behind foundation drainage layer.

Design: designer

Construction Trades: foundation contractor, framers, insulator, foundation drainage layer trade, grading

The Bay

The Bay
The foundation could be simplified by leaving the foundation wall as a straight line and creating the bay by cantilevering the floor joists or the bay window itself. Effective air barrier detailing can deal with potential discomfort concerns.

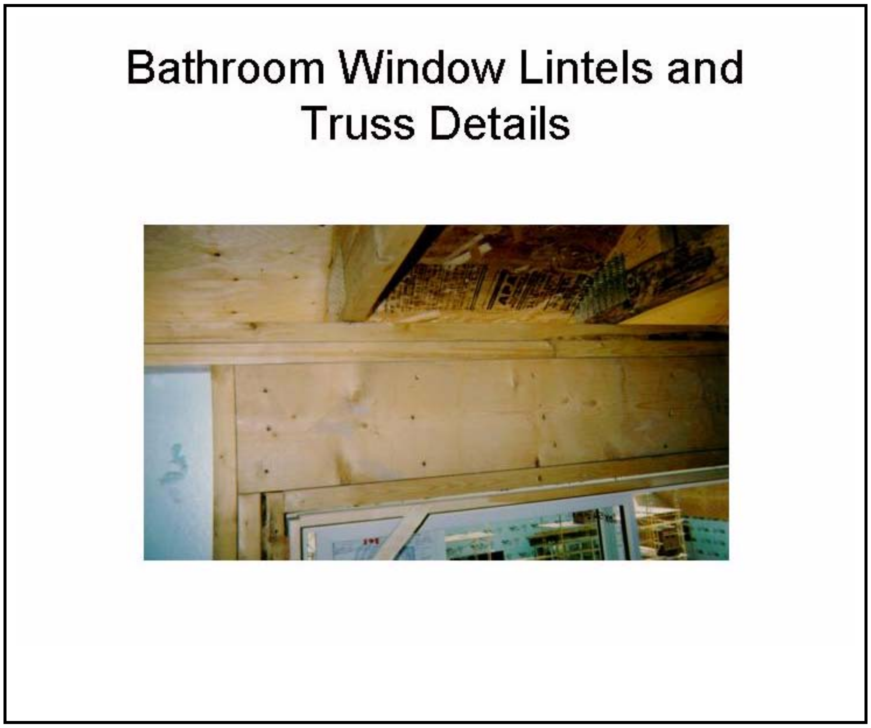
Design: designer

Construction Trades: foundation contractor, framers

Window Opening
This is an example of triple jack studs used on the first floor. It would make sense to review whether a parallam lintel is required (depending on the load above) and further why the lintel needs to be supported by triple jack studs. In addition, the need for the floor framing to be at 12 inch centers should be reviewed. Less costly alternatives to consider might include: engineered floor bridging, 3/4 plywood or OSB sheathing.

Design: designer

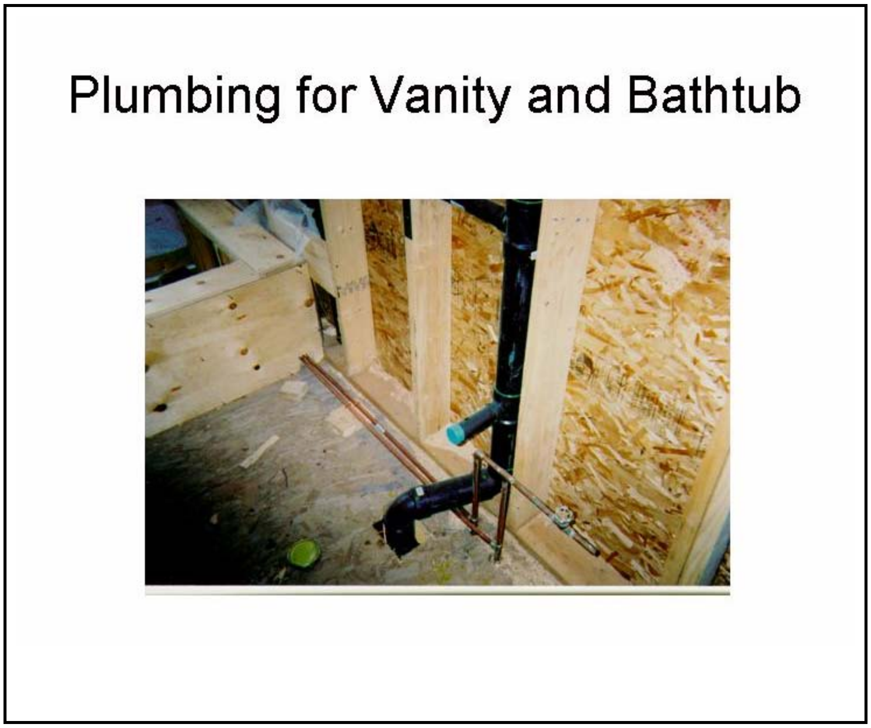
Construction Trades: framers



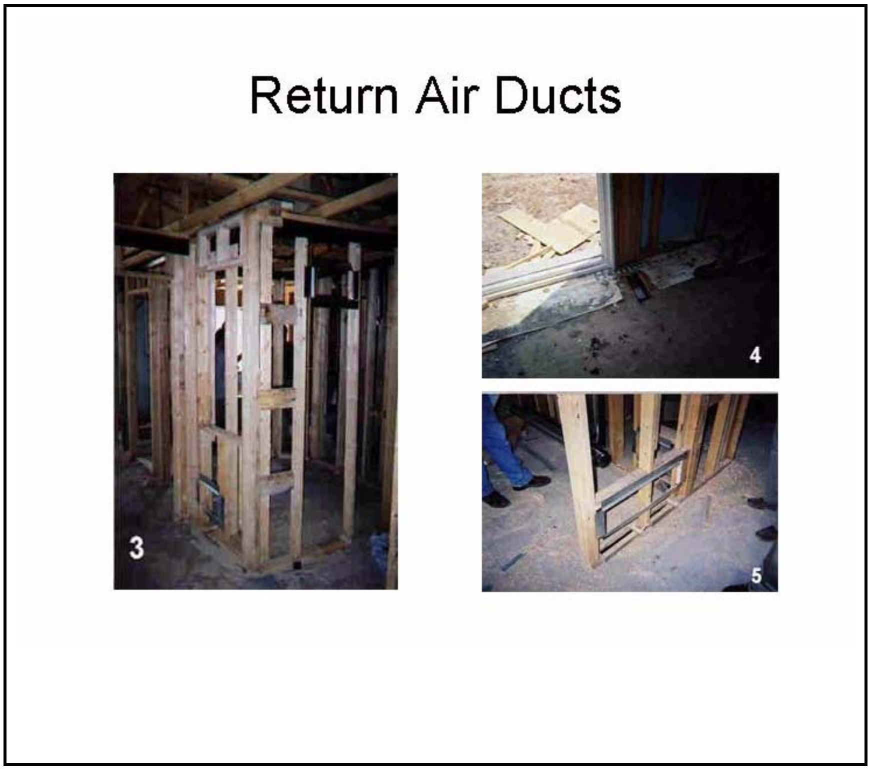
Bathroom Window Lintel and Truss Details
Once again the lintel over the window is supported by double jack studs where only one is required. It is fortunate in this area that foam sheathing is being applied to the exterior, as the many wood elements in this area would have considerable potential for cold surfaces and moisture problems. The trusses are standard. Consideration should be given to a modest raised heel and cardboard baffles to improve insulation (minimizing wind washing) and attic venting (minimizing ice dams) in this area. At a minimum, OBC insulation levels need to be maintained at the top plates and venting maintained into the attic.

Design: designer

Construction Trades: framers



Plumbing for Vanity and Bathtub
The area behind the bath tub is an area of great concern for insulation and air / vapour barrier detailing. If possible one should consider installing insulation, polyethylene and boarding before letting the plumber install the bathtub. The way the pipes are located necessitates that the vanity be dramatically cut on site as they are too high to be located under the kick.



Return Air Ducts

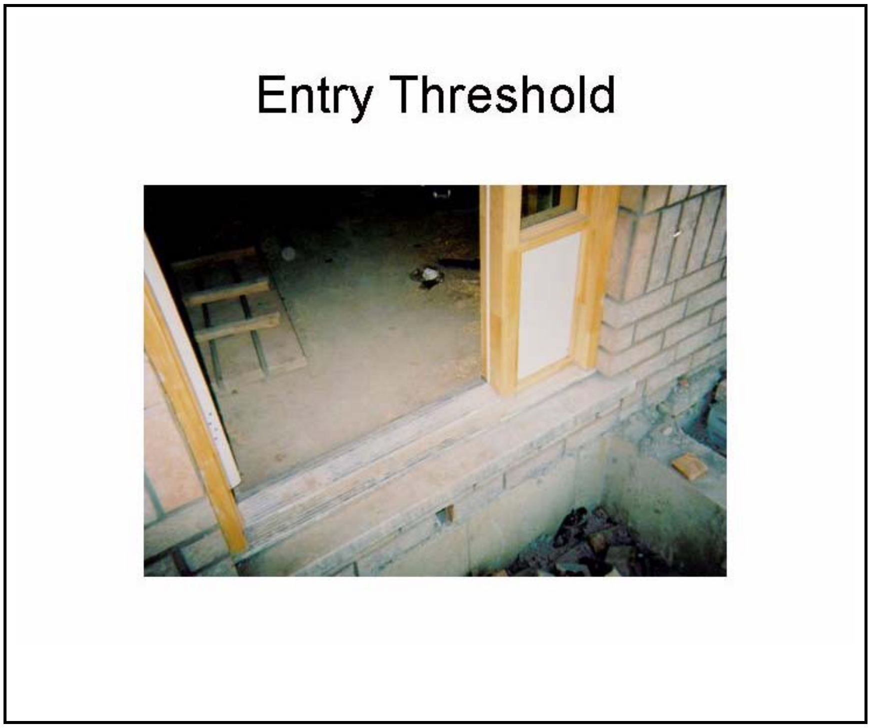
The return air system for the house uses a collection of low & high wall cavity returns. In at least 2 places (upstairs and on the main floor), there are 2 return air grilles in close proximity that could be combined so that one could be eliminated. This would reduce labour and material costs. In general, it would be better to create fewer return air runs and do a better job of sizing and planning for their location.

While there does not appear to be any hard data on window condensation complaints, site staff indicated that as many as one third of homeowners had problems with window condensation. Minor upgrading to the "Principal Fan" ventilation system should be considered. Either upgrading one fan to a quieter unit with a timer control or going to a central in-line fan for 2 or 3 bathrooms can be accomplished for less than $200.

The heating vents in the kitchen are poorly located. This location makes it difficult to properly finish the ceramic tile floor and provides poor heat distribution across the patio door.

Design: designer

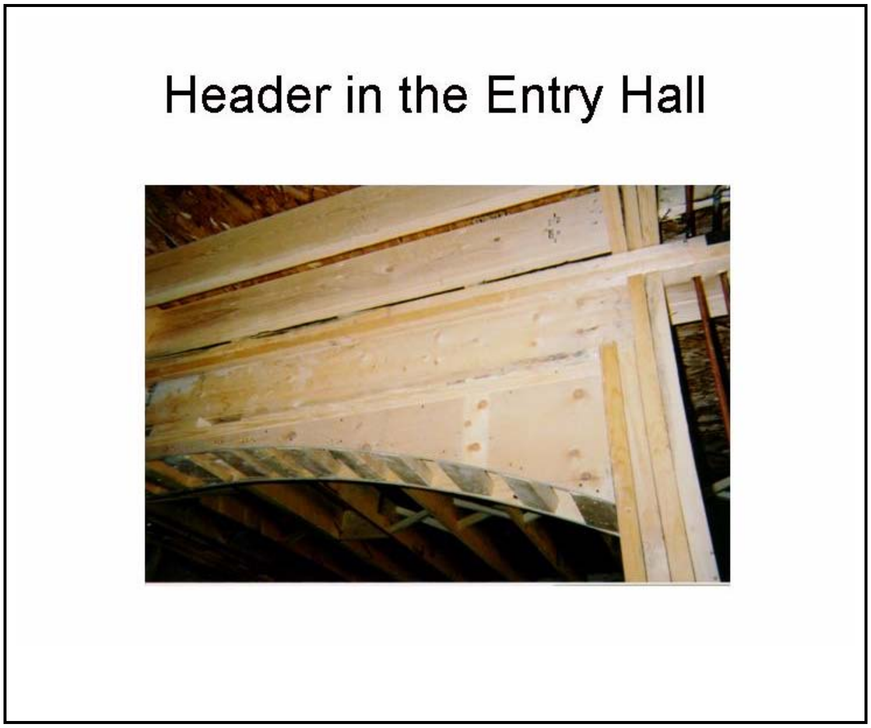
Construction Trades: heating contractor



Entry Threshold
It was noted that the masonry threshold often comes loose and needs to be re-laid by the masons. It is recommended that the door be moved forward in the opening to lessen the likelihood of people stepping on the threshold and causing it to become loose.

Design: designer

Trades: brick layer, door installer, framer

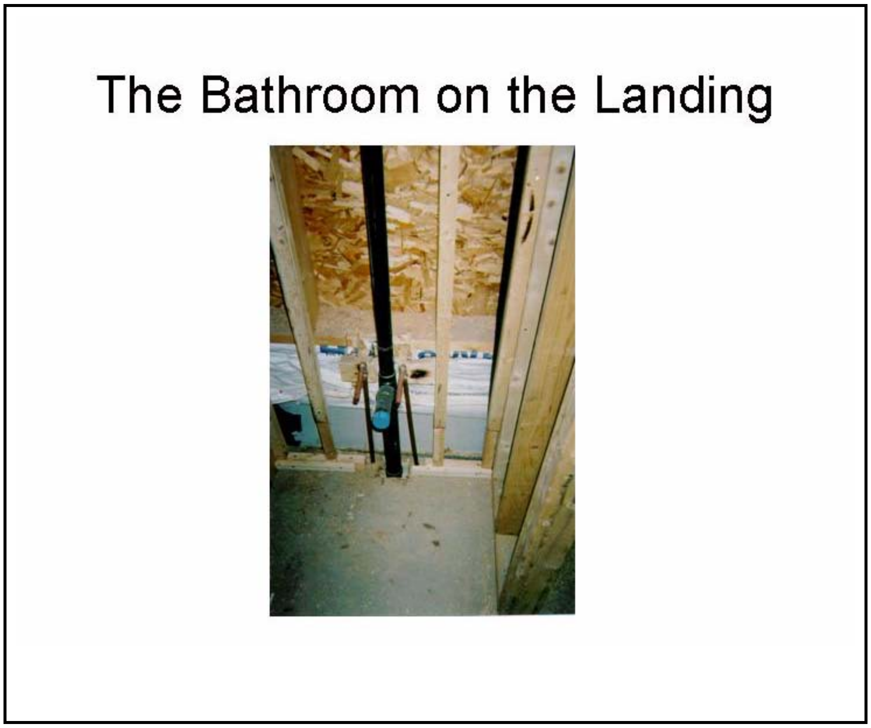


Header in Entry Hall

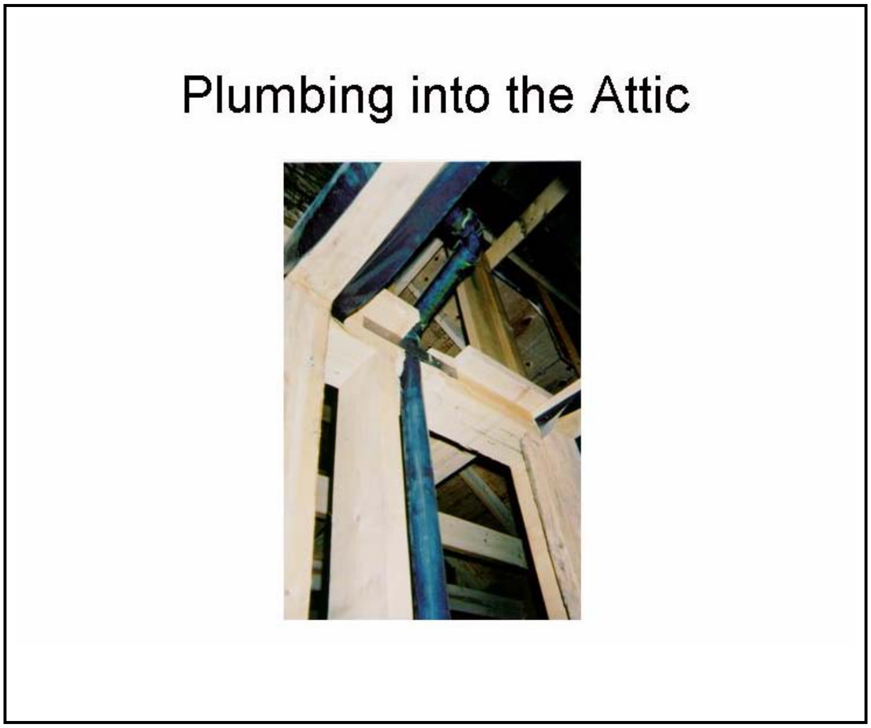
The decorative arch as is in place between the living room and dining room as is constructed in photo should be sufficient. The lintel over the opening and the double jack studs are not required as the floor joists span the opening above. Nor is it clear what the point load above is that necessitates a post to be in place. There is a liberal use of double and some cases triple jack studs at door and window openings that could be eliminated.

Design: designer

Construction Trades: framers

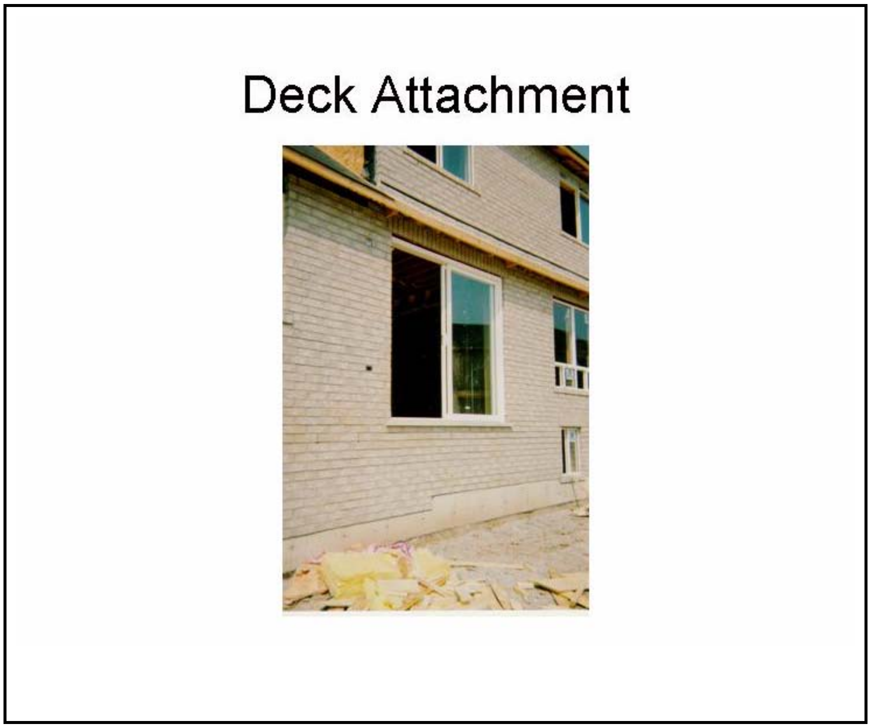


Bathroom on Landing
This photo is taken from the hall on the landing en route to the basement where there is a small 2 piece bath. From the details it appears that there will be very little insulation behind the plumbing pipes in this area, which could result in freezing problems, especially if insulation is placed in front of the pipes.



Plumbing into the Attic
Here is another example of the trades not using a hole saw, which results in an attic penetration that is extremely difficult to air seal. This may lead to considerable air leakage into the attic resulting in moisture problems.

Construction Trades: framers, plumbers, insulators



Deck Attachment
The provision for the wood deck attachment could have been incorporated into the wall assembly. Attaching the deck as an afterthought may increase cost.

Design: designer

Construction Trades: framers

Summary
The construction review resulted in a list of twenty one items to be considered by Builder E:

1. Framing - i) bathroom over entry door
   ii) posts
   iii) bedroom over garage
   iv) bedroom dormer
2. The window
3. The wall between the garage and kitchen
4. Kitchen bulkheads
5. Underside of first and second floor
6. Tall wall by the stairs
7. The dormer and roof girder truss
8. Heating of room over garage
9. Heating system - overall
10. Air sealing
11. Brick ledge
12. The bay
13. Window opening
14. Bathroom window lintels and truss details
15. Plumbing for vanity and bathtub
16. Return air ducts
17. Entry threshold
18. Header in the entry hall
19. The bathroom on the landing
20. Plumbing into the attic
21. Deck attachment

5.2 Design and Defects Review

The service manager, construction staff, building officials and designers all participated in a meeting to identify and describe the most significant defects Builder E encounters.

As a result a master defect list was developed. The list included all items from the construction review and included items identified by service staff and the town's building department. Participants chose the defects they believed were most important from the list. These are identified by numbers in parentheses which correspond to the number of individuals who have short listed the defect.

Summary lists of all of the top issues the Building Canada team should address are presented. These are categorized as items arising from the review of as-built construction, service issues, and building official issues.

Top Service Issues

1. Floor joist squeaking (bridging rock on plywood) (3)
2. Knots bleeding exterior (2)
3. Shower stall leaks (floor pan damage) (2)
4. Windows operation (foaming) (2)
5. Gap not below window, brickwork (1)
6. Countertops water damage (1)
7. Expansion/contraction - heating ducts (noise) (1)
8. Ceramic tile settling (cracks) (1)
   i) replacement costs
   ii) dye lots
9. Cold bedrooms (windward face)
10. Floor joist crowning
11. Recessed second floors with brick veneer

Top Building Official Issues

1. Garage drops, vapour barriers (3)
2. Truss installation from details (1)
3. Semis/towns - party walls (1)
4. Fire stopping - 2' side yard - fire resistance rating
5. Framing (e.g. IBS) not according to specs

Final Top Issues List for Builder E

1. Garage ceiling under bonus room detail
2. Knots bleeding through exterior siding
3. Shower stall leaks (floor pan damage)
4. Window operation and foam installation
5. Low E windows
6. Floor joist squeaking
7. Deck attachment
8. Truss redesign: attic truss over bonus room and eliminating laminated truss
9. Alternative Floor layout
10. Mechanical system

5.3 Defect Analysis

The Building Canada team attempted to analyse each defect from the Final Top Issues List and to provide a commentary to guide Builder E through the next stage of the process as shown below:

Top 10 Issues List Building Canada: Builder E

1. Garage ceiling under bonus room detail / Underside of dormer detail

The proposed garage redesign uses a combination of attic trusses and hand framing for the garage floor/roof. The steel beams and posts in the garage walls are no longer required, reducing both cost and eliminating thermal bridging. The infill floor between the girder trusses on either side of the dormer will be hand framed. An adjustment will need to be made in the height of the garage wall as there will be a 2" difference in joist depth (main house and bonus room). The resulting garage ceiling will now be all on one plane which should simplify the insulating, air sealing and finishes.

The steps to follow are i) seal the duct work ii) install batt insulation iii) install 1" of foam on the underside of the joists iv) install a continuous air barrier either by taping the foam or preferably installing an air barrier membrane and sealing any penetrations v) install drywall. The header and air barrier membrane must be carefully sealed to prevent air penetration into the floor assembly.

The underside of the dormer floors, with the redesign of the roof layout will make it easier to insulate and air sealing by following the steps as outlined above. If the toilet location were exchanged with the sink in the center dormer, plumbing could be relocated to eliminate any penetrations through the floor of the dormer in the overhang area.

2. Knots bleeding through exterior siding

Bitumen and tar from knots bleeding through paint while seemingly a simple problem to solve is somewhat more complicated for the production builder. Painters have traditionally used shellac as a sealer with limited success. Shellac is used because of its rapid drying time, allowing little or no delay in the painting process.

Considering the extent of the problem and the cost to the company are essential to formulating an appropriate solution. Possible solutions to the problem include:

- Clean and repaint bleed through areas (current solution)
- Clean and re-seal with aluminum paint and repaint
- Pre-seal with aluminum paint (builder-supplied labour)
- Pre-seal with aluminum paint (painter-supplied labour)
- Use clear lumber
- Use pre-primed lumber
- For fascias use aluminum or stucco clad lumber
- Use non-lumber siding (i.e. Hardi Plank)

Using an aluminum paint as the knot sealer can be an effective solution but requires additional time for drying. Typically painters are unable to seal and paint the same day when aluminum sealer is used. Knots will need to be treated before the painter arrives on site. Credit should be negotiated with the painter after the new process has been implemented and new margins are better understood.

3. Shower stall leaks (floor pan damage)

Shower stall pan leaks are not uncommon problems. Tile setters are generally blamed for leaks, although other trades can cause damage from dropping tools and nail holes. To eliminate the problem, it has been suggested that the pan be filled with water prior to the tile setter arriving on site. Care should be taken to monitor the pan to ensure leakage doesn't lead to wetting of floor assemblies. Assuming there are no problems with leaks, the filled pan should signify that it has not been damaged and that any subsequent damage will be reasonably backcharged to the tile setter.

4. Window operation and foam installation

Foaming around windows and doors – when done well, foaming around windows and doors is an excellent option to achieve an air barrier, vapour barrier and high quality insulation, but it does require the right foam, a good foam gun and proper technique. It is not how much but how well the foam is applied. The wrong application may distort the frames and result in numerous operational problems. Builder E specs should be adjusted to list new requirements for the insulators so that problems can be corrected / avoided.

Clearances for brick below windows has been reported as an area of concern, but Builder E reports significant efforts in attempting to rectify the problem. A wood I floor assembly using the proper joist header material would greatly reduce or eliminate the clearance problem for the brick below window openings. Sawn lumber experiences greater shrinkage than wood I's and is the major cause of the problem, especially for second floor windows where the problem becomes cumulative.

5. Heating system location and duct layout

The heating system for this house was tight sized very close to the theoretical heat loss determined by calculations. This leaves little room for cost reduction from optimizing its size. While a smaller furnace can save $50 - $75, typically the its size is determined by the fan airflow requirements for cooling. Typically, furnaces with smaller heat outputs do not have enough airflow to accommodate cooling requirements. (Refer to the discussion on Low E windows).

Mechanical system savings will result by eliminating duct runs or branches (since all labour is piece work and the length or size of runs has only marginal material cost implications). Some small savings can possibly be realized by reducing trunk sizes.
In the house investigated the furnace was installed near the front of the house. This required a long, large main duct running to the back of the house before it was split to serve the two sides of the home. The areas hardest to heat and cool – the room over the garage and upper master bedroom - have the longest effective duct lengths. Furthermore, the larger duct run reduces headroom and makes basement finishing awkward. It is proposed that a better location for the furnace would be behind the rear garage wall with a main duct running from side to side rather than from front to back. This is assuming joist layouts were adjusted to accommodate duct runs. This would eliminate approximately 20' of main duct and at least one large 90o plenum turn. This should result in savings of approximately $200.

Savings can be realized through rationalization of the construction of rooms over garages. By eliminating the heated plenum under the floor of these rooms, at least one supply and return run can be eliminated. This results in savings of at least $100.

If truss joists are used on the second floor, then we would propose using a riser plenum system common in other areas of North America to serve part of the second floor rather than the individual risers commonly used in Canada. For example, one six inch riser could be used to service the three ducts running to the front of the house. Priced properly this should reduce costs slightly and improve overall system performance.

We would propose eliminating the supply duct run in the powder room. Although HRAI manuals require duct runs in each room in the house, the heat loss and gain of this small room is minimal and we can easily demonstrate the lights within the room provide adequate heating capacity and the exhaust fan provides adequate cooling and ventilation capacity. Every duct run eliminated should reduce costs by $50 - $75.

Finally, with the proposed changes in air sealing and draft stopping details, upgrading the central ventilation system is recommended. This will reduce condensation callbacks and improve house performance. The least expensive option would be to upgrade the existing principal exhaust fan to a quieter (under 1.5 sones from the current 2.5 sones) and add a "FanCycler" timer to allow the fan to run approximately 30% of the day – along with the furnace fan. This would dramatically improve air quality and control moisture in winter. Total installed upgrade cost would be approximately $200. Another option would be to eliminate the current powder room exhaust fan in favour of a good central exhaust mounted in the basement and vented back from the powder room (or any other bathroom). Again this fan would be controlled by a timer and manual switch. The installed cost would be under $300 and would have the additional advantage of allowing easier substitution of other central ventilation devices such as air exchangers. It would also eliminate the noisy powder room fan.

6. Floor joist squeaking

The reasons for squeaking floors are many and could include:

- subfloor riding up and down on nails
- nails rubbing against hangers
- drywall creaking against underside of floor joists
- movement of subfloor
- movement of underlay over subfloor

Persistent floor squeak problems should be approached systematically. Recommendations to reduce or eliminate problems include:

- Lumber should always be stored to avoid wetting as wood shrinkage is a major source of problems.
- All subfloor edges need to be supported by tongue and grooves or with framing beneath.
- Persistent problems may require gluing and screwing of the subfloor.
- Hanger squeaks should be identified where possible before ceiling drywall is installed.
- Ensure creaking is not the result of differential movement between the floor joists and ceiling.
- Avoid flush beams wherever possible, they require many hangers, and often result in humps in the floor. Installing the needed hangers is time consuming and can often result in problems routing plumbing and heating runs.

7. Low-E windows

Low E windows are recommended as they will help control indoor window condensation, as well as improving occupant comfort and reducing heating and cooling loads. While Builder E only offers cooling as an option, many duct sizes and often the furnace blower sizes are determined by cooling loads. In this model, cooling load reductions were in the order of 0.3 tons. A critical room such as the living room if facing south has marginal cooling performance if two 5” diameter ducts are used for heating and cooling where Low E glass is not used. With Low E, those same two ducts will do a good job in cooling mode. In other models Low E glass can save up to 0.5 tons of cooling and reduce airflow requirements by 200 CFM. Key design features of Builder E’s homes are the large glass areas and any one model may end up in any orientation on site. Low E glass would provide greater consistency in mechanical system design and layouts across model types and result in fewer complaints about cooling performance on second or third floor rooms. Low E coatings would also result in warmer glass temperatures and thus reduce window condensation potential. Window suppliers currently charge a significant premium on Low E orders because they have to shut down the entire production line to run it. Actual material costs are in the 5% premium range and the window company does make up its own glazing units so they are able to do Low E or argon or both. Typically Low E represents a $500 - $800 upgrade on a standard window package. As Builder E’s window supplier already uses an insulated spacer technology, this would not represent an upgrade. Nonetheless, insulated spacers are recommended regardless of supplier.

8. Deck Attachment

No deck attachment elements were provided for at the framing or exterior finishing stage. This oversight can at times cause the inadvertent attachment of the deck to the veneer rather than directly to the structural wall. Lag bolts should be installed before the brickwork is laid.

9. Truss Redesign

The main roof redesign will establish an interior load bearing wall using existing elements and the introduction of a simple beam in the second floor to span the dining room. This will eliminate the need for the girder truss and posts that currently carry the main roof elements. The complete roof will be manufactured elements except for the porch overhang, the floor of the dormers and the dormer walls which would be hand framed.

The redesign would introduce a modest raised heel to the truss design. This would add a small premium to the cost of construction but generally represents good value in increased insulation, reduced incidence of wind washing and the risk of ice dams as well as providing a nailing surface.

The roof of the 4 dormers will be trussed and shipped with the roof package for simple installation. The design would also eliminate the need for headers over the dormer windows and jack studs which will simplify construction, eliminate hand framing and improve insulation strategies.

The new truss design would also eliminate the need for a header and jacks over the window located on the landing in the stairs opening. The framers would just need to scab a 2 x 8 on the side of truss cord displace the roof load.

The proposed roof package would be about $2,500 more than the current package, less the deductions for lumber, beams, headers and jacks. The real savings is in time and labour. These are of no consequence to the individual framer, but may represent increased margin for the carpentry company. The new roof package is estimated to allow the building to close about 2 - 3 days faster than the existing roof package. Builders and trades would each receive their draw sooner, the building would be under cover sooner, and the whole building would close sooner.

Design the roof at the same time as the plans: Each lumber supplier currently provides their own roof package and design, so on some occasions the builder isn't comparing apples to apples which in some cases results in nasty surprises. The process is time consuming and means that the plans aren't submitted for permits until a supplier has been picked which sometimes translates into big delays in getting started.

Providing the suppliers with a roof design to quote on will speed up quotes, ensure everyone is quoting on the same design, and means the builder can apply for permits much earlier in the process. Builder E already does this with the lumber package by having someone on staff do the material takeoffs. These takeoffs are then used by the suppliers to prepare their bids.

10. Alternative Floor Layout

The primary recommendation is to substitute the current use of 2" x 8" joists with a layout using wood I joists. The primary rationale for the recommendation is:

- the simpler layout,
- the fewer pieces to handle,
- elimination of the mixed use of cross bracing and engineered bracing,
- additional room for mechanicals,
- less shrinkage,
- fewer squeaks and nail pops,
- fewer beams and posts,
- fewer direction changes, and
- less costly for materials.

The proposed floor is currently a mix of wood I's on 16", 19.2" and 24" o.c.

The project team intended to eliminate the 19.2" spacing but in some areas the spans required it be kept. The 16" spacing is limited to areas that will have ceramic tile installed. The use of wood I's eliminates issues around crowning joists.

The floor sheathing is proposed to be 3/4" thick OSB. Beams and posts are eliminated making utilities easier to install, there is no bridging required. The system minimizes bounce and squeaks, creating a sales opportunity and eliminating callbacks at the same time.

The floor is significantly easier to frame and the new design should be faster to install. While there should clearly be improved margins for the carpentry trades it is acknowledged that there is a reluctance of the trades to accept new methods or to pass on labour savings.

Wherever possible, basement windows should be modularized and laid out to coincide with the floor joist layout. Windows in walls where appropriate should also be modularized wherever possible.

Insulating and air sealing the Joist Headers - while properly installed header wraps would be effective at creating air barriers in the header area, this has proven to not be a realistic or effective option for most production builders. Spray urethane foam could be a very effective at providing an air barrier, vapour barrier and high quality insulation. It would seal around all penetrations, dryer, fans, furnace, hot water heater, electricals etc.

Given Builder E's buying power this could be very cost effective option for first floor assemblies, second floor assemblies and dormer floors. Consideration could also be given to foaming the garage floor if the price was reasonable enough. Windows and doors could also be done by this same crew using a low expansion foam.

Other Comments

Real opportunities only present themselves at the time of tendering a new project. When suppliers and trades are asked to tender for new phases of a project opportunities are created to introduce new specs reinforcing the notion of consultation and post-project evaluation. Realistically, a demonstration building is needed to test the new specifications, construction and pricing. Intrinsically this implies long lead times validating the typical 3 and 4 year project duration evident in the Building America experience.

Central Lumber has provided a new layout of the floor and roof system for the Builder E Building Canada house. Central lumber expressed confidence that even greater dividends would be available if this exercise began earlier; for example, changing the bearing wall in the basement, so that all the floor joists could run in the same direction.

Tall walls - the current tall wall design by the stair opening is framed using 2 - 2x6s 12" o.c. It seems this spec changes from municipality to municipality (as is evident in the Construction Review section). Discussions with Central would suggest that 2x8's 12" o.c. would be sufficient, easier to frame, less expensive material wise and use standard insulation. It would make sense for Builder E to do some engineering in this area to develop 2 standard walls - one for bearing walls and one for non load bearing. The landing should be considered in adding rigidity to the wall elements.

5.4 Building Canada House Construction

Builder E constructed their first Building Canada house over a span of a few months. A number of decisions internal to the company took the construction of the first Building Canada house in directions not established at the outset of the project. Changing responsibilities for the project further exasperated the problem. To follow is a documentation of the construction of Builder E's first Building Canada house.

Framing

Simplified Floor Framing
The Build Canada Team suggested the elimination of dimensional lumber for the floor framing system instead an engineered lumber system was chosen. This represented an approximate $950.00 upgrade which would be recovered through a value engineering process and through labour savings. Advanced strongback joist contained three openings per joist that reduced the need for notching and drilling and easily accommodated services (see figure 5.1 and 5.2). Joists were laid out in three distinct rows, running front to back for both the first and second sub-floors. Each row contained the strongback access windows. This also served to eliminate or reduce: 1) floor humps resulting from changes in joist direction, 2) engineered bridging, 3) point loads, 4) lintels, and 5) bearing partitions. The floor framing changes appear to reduce the time required to frame the floor. An estimate of the likely time saving would be in order at least 2 hours per floor. Time associated with subfloor cutting and running services.

Figures 5.3 and 5.4 show use of the strongback Joists.


Figure 5.1


Figure 5.2


Figure 5.3


Figure 5.4

Bedroom Over Entry

The bedroom over an entry or other unheated space has been a source of homeowner comfort complaints and customer service issues due in large measure to air leakage within the insulated floor space. Figure 5.2.1 shows the subfloor wrapped in house wrap, the cavity later to be filled with blown in cellulose insulation. Air sealing was simplified by eliminating a complex beam / header joist configuration. Solid blocking between the joists had to be custom cut to accommodate the top and bottom chords of the engineered joist.

Figure 5.5

Bedroom Over Garage

The floor of the bedroom over garage poses a challenge for all GTA builders. It can generally be dealt with in two ways: 1) by a warm-air pressurized plenum constructed beneath the subfloor and above the insulation or 2) by foam sealing and insulating the entire floor from the garage below. Historically, for this builder, this area has been the most prevalent source of air leakage and homeowner comfort complaints. These problems were dealt through: 1) a simplified floor framing system, 2) the use of solid blocking, 3) header wrap and 4) a foam air sealant applied around the perimeter with cellulose insulation blown into a drop ceiling.


Figure 5.6


Figure 5.7

Basement Windows

Ideally, all basement windows should be installed below the subfloor to eliminate costly, time consuming framing and finishing details (see figures 5.9, 5.10 and 5.11). These beam / header combinations add to the cost of floor framing but are a lower cost alternative to window wells, including the associated drainage. Examining the specific relationship of each house to the site can eliminate this detail in most instances. Care must be taken to reduce air leakage in these locations through the use of header wrap and foam sealant.

Basement window headers become a real issue when the basement window is perpendicular to the direction of the floor joists. This requires double joists on either side of the window and a double header to pick up the intermediate joist that must be installed with joist hangars. Joist hangars have been known to result in floor squeaks, (from improper installation or wood shrinkage). The use of engineered flooring may eliminate a majority of these complaints. The wall load is transferred through a lintel installed above the level of the subfloor.

Figure 5.9


Figure 5.10


Figure 5.8


Figure 5.11

Double Wall Between Kitchen and Garage

Traditionally the double wall between the garage and the kitchen (or any other conditioned space) has been used to accommodate mechanical systems and still achieve the required R-value. Typically this requires the air barrier (poly) be installed between the two walls during framing. The implication is that this air barrier is often damaged by the trades or installed improperly in the first place. Elimination of this double wall was possible with the advanced mechanical system used in this house. Elimination of the double wall would save lumber and reduce air infiltration.

Figure 5.12

Kitchen Bulkheads and Media Centres

In order to install a media centre, bulkheads or any other boxes with optimal air sealing, the walls must be insulated first and the poly air barrier must be fastened to the plates with the use of a mechanical clamp (such as a strip of plywood). Builder E has successfully built R-2000 homes, using this technique.

Figure 5.13

Making a Drop-Beam an Architectural Structure and as a Chase for the Mechanical System

A load bearing LVL drop beam was required to eliminate changes in joist direction. The LVL was incorporated into an architectural archway that also served as a chase for the heating system. Numerous three-ply lintels and one steel I-beam were also eliminated.

Figure 5.12

Deleting Point Loads

By running the entire subfloor joist system front to back, it was possible to eliminate all bearing wooden beams, steel beams and bearing partitions running parallel to the joists. This resulted in significant financial savings. This also simplified the job of the back framer who picked up and extended the point loads through to the foundation.

Figure 5.13

Deleting Flush Beams
All flush beams resulting from changes of joist direction were eliminated. Again, this was a direct result of running all the joists in one direction. The only exception was a flush beam on the second subfloor that spanned across the front hallway. It was decided that a drop beam was not appropriate in this location

Figure 5.14

Deleting Engineered Bridging
Engineered bridging can extend the spans of dimensional lumber. Currently priced at $8.00 each, extra pieces are often discarded by clean-up labourers. Engineered floors completely eliminate the use of this expensive product.

Figure 5.15

Eliminating Changes in Floor Joist Direction

Changes in the floor joist direction were accomplished through the use of engineered flooring running front to back. In doing so, this eliminated numerous problems: floor humps, floor squeaks, elimination of lintels and headers, flush beams, simplified framing, elimination of joist hangers and plywood waste reduction. This figure shows the only flush beam in the first and second subfloor, over the front entryway.

Figure 5.16

Tall Wall First Floor

The stairway tall wall appears to be one of the most poorly designed features for most production builders in the GTA. This wall usually consists of double 2X6 members with intermediate girths, either 18 or 20 feet tall, at 12 inches o.c. The tall wall was eliminated by building a 2X4 knee wall at 16 inches o.c. from foundation to first landing. The first landing would bear directly onto this knee wall. A second 2X4 wall at 16 inches o.c. would sit on the first landing and provide a bearing surface for the second landing. Another 2X4 wall at 19.2 inches o.c. would extend from the second landing to the roof line. On both landings, it is imperative to use a header wrap to reduce air infiltration. This system of construction, although more complex in terms of air sealing, represents significant savings in lumber costs.

Figure 5.17

Figure 5.18

Window in Tall Wall Second Floor

The lintel in the window in the second floor tall wall was totally eliminated by spanning a single 2X8 above the top plates and sufficiently nailing it to the gable truss. This process served to reduce shrinkage, lumber and thermal bridging.

Figure 5.19

Dormer Trusses

To simplify framing, conventional roof framing was eliminated to the extent possible. This included the front four dormers. The dormer over the garage has a scissor truss (cathedral ceiling), while the other three had a conventional flat ceiling

Figure 5.20

Lintels in Dormers

The use of structural, end bearing trusses on the dormers eliminated the need for any lintels. This served to reduce shrinkage, lumber and thermal bridging in the conditioned space.

Figure 5.21

Roof Girder Truss

The original roof plan called for a four-ply girder. The girder basically joined the front third of the roof to the back two-thirds. In an attempt to eliminate the girder, this design would add an extra $1500.00 to the cost of the roof framing. This idea was abandoned in favour of eliminating as much conventional framing as possible for a similar cost.

Figure 5.22

The Triple Truss Problem

It was decided to truss as much of the roof as possible. The new truss configuration was three sets of trusses: one at the back over the kitchen area, the main trusses from the back of the house into the four-ply girder, and smaller sets of mono trusses that spanned from the four-ply girder to the front of the porch. Theoretically, this system appeared to be the best fit for the house (figure 5.23); practically, it did not work out that way. The forming contractor for the foundation poured the basement two inches too wide. As a result, the front mono trusses were misaligned and did not match the plane of the roof above (figure 5.24). This error was within the tolerance level for foundations as per scopes for Builder E, but was not within the allowable limits for truss end bearing. In order to fix this problem, a series of two-ply 2 x 8 beams was set up to span between the dormers (figure 5.24).

This "Cape Cod design" is not unusual for Builder E. After discussions with the framers, the team concluded that it was far simpler to hand cut the roof. The other solution would be to tighten up the scopes of the forming crews, but that in itself would present a whole new set of problems, such as back charges and price increases. A second solution, and probably the best one, would be to put in an extended heel on the end of the trusses over the kitchen. This would allow the framer to cut off the extension (which would fit into a joist hangar) to suit the width of the building. This extension should be at least six inches and would have to be engineered by the truss manufacturer. A third solution would be to tighten-up the scopes of work and tolerances for the forming contractors. This item should be deferred to the contracts department for their review.

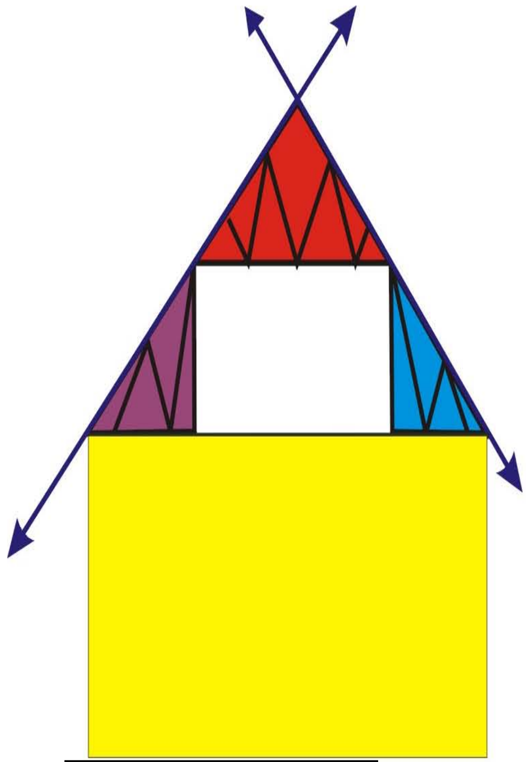


Figure 5.23

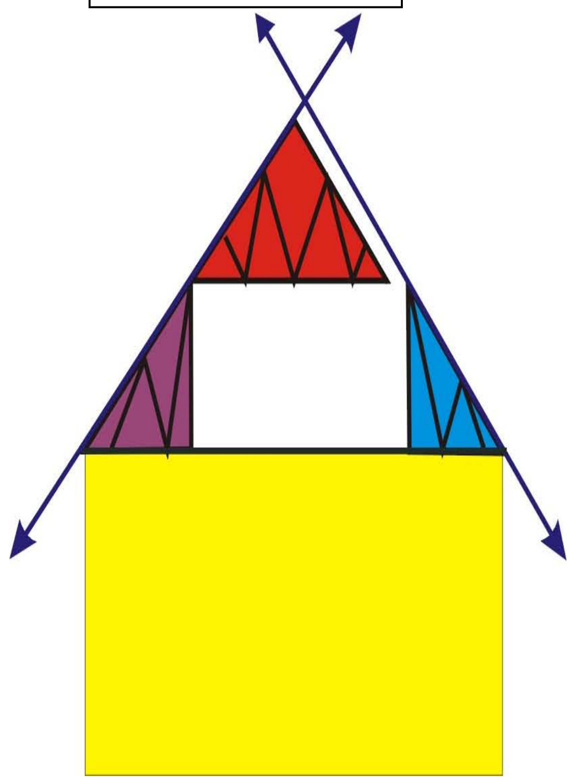


Figure 5.24

Garage Drop Ceiling

Traditionally, GTA builders treat the garage drop ceiling by including a heat run and a cold air return within the drop. This tends to be both expensive and also contributes to considerable heat-loss. An alternative was built as follows:

1. Header wrap encases both the sub floor and the I-beam.
2. Fire stopping (in the form of 3/8 inch plywood) must be installed around the entire perimeter, behind and above the drop ceiling.
3. The distance from the bottom of the drop ceiling to the under side of the floor joist measures 16 inches.
4. Stopper batts are required between all trusses.
5. two-part foam air-sealing is required above the drop-ceiling.
6. A 24 inch by 32 inch access hole must be framed in the center of the drop ceiling.
7. All joints of the heat runs must be taped.
8. Any intentional openings resulting from mechanical installations through the sub floor to above must be sealed.
9. Cellulose Insulation is then blown into the cavity to the bottom of the floor joist
10. Piece of vapour barrier installed for visual inspection purposes. The remainder of the cellulose is blown behind the vapour barrier. Remaining drywall installed and gas-proofed.

The airtightness achieved by header wrap alone has not been acceptable for this builder. While the cellulose provides some additional airtightness the two part foam was seen to be important to achieve the desired level of airtightness.


Figure 5.25


Figure 5.26


Figure 5.27

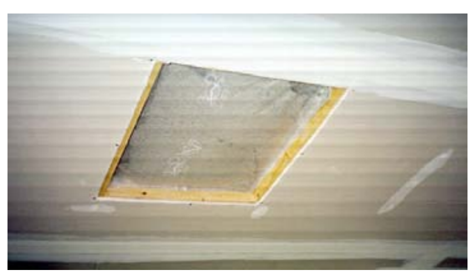
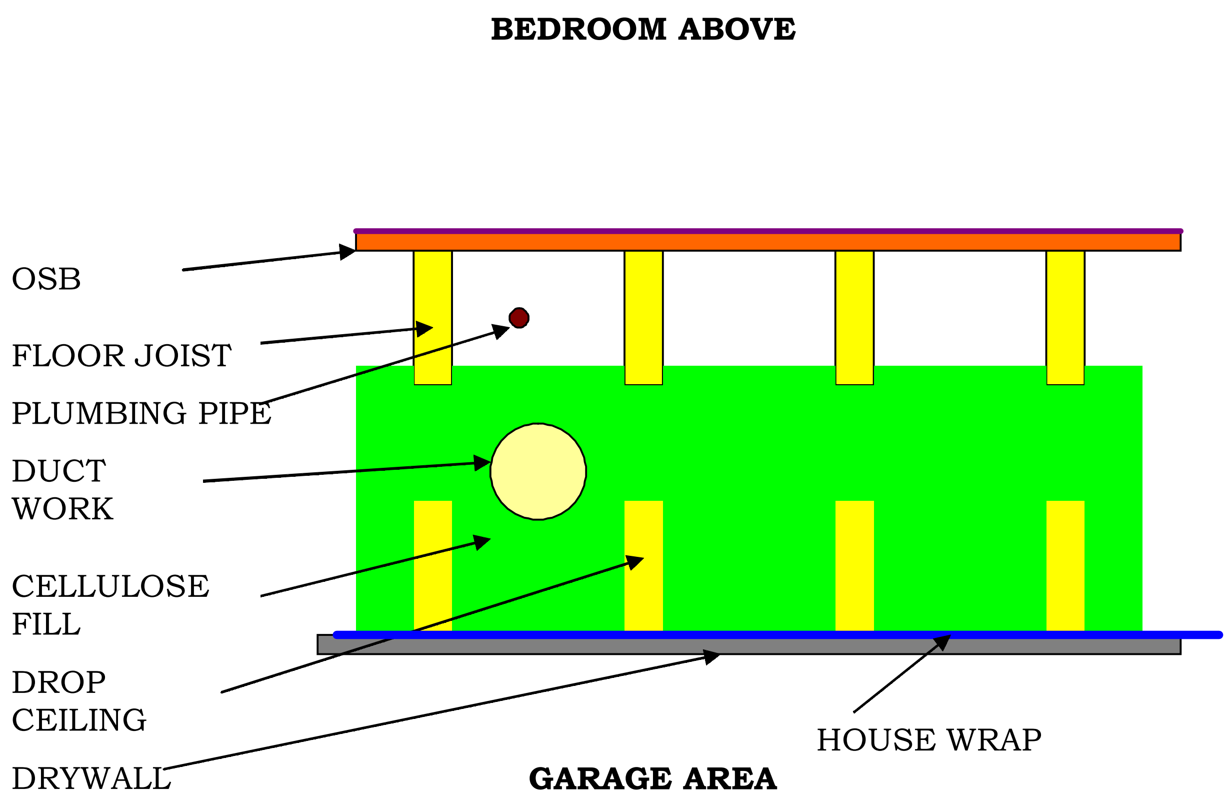
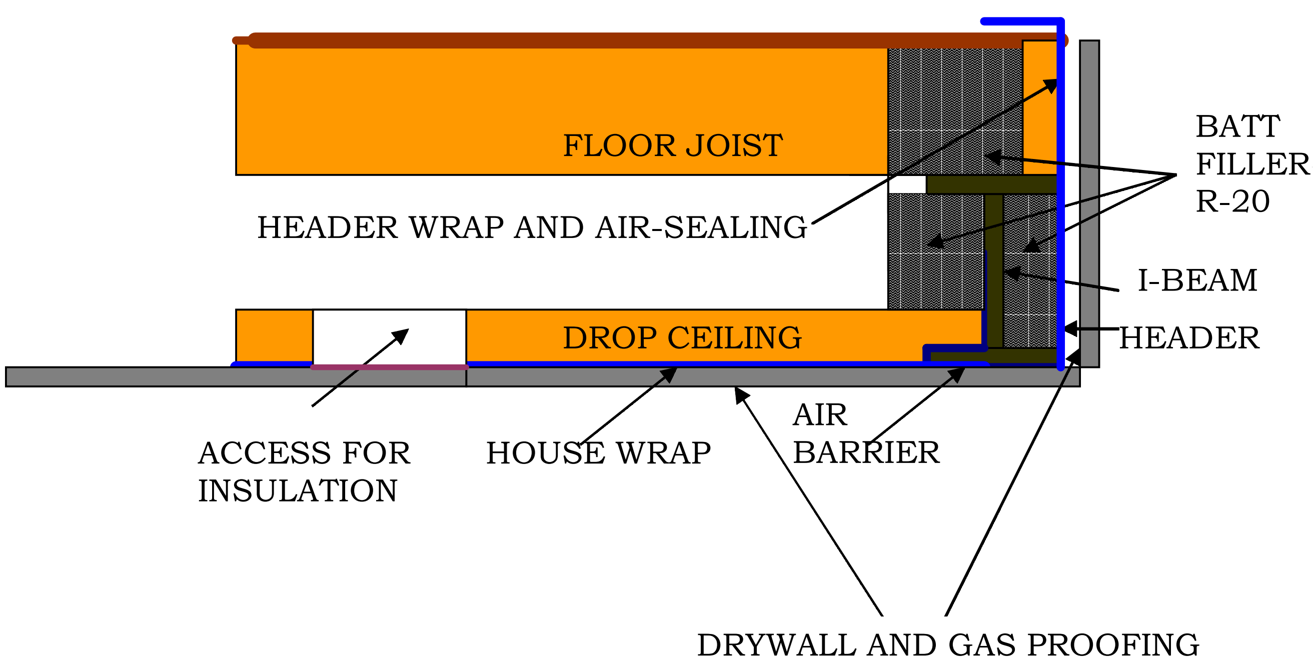


Figure 5.28


BEDROOM ABOVE
OSB
FLOOR JOIST
PLUMBING PIPE
DUCT
WORK
CELLULOSE
FILL
DROP
CEILING
DRYWALL
HOUSE WRAP
GARAGE AREA


FLOOR JOIST
BATT
FILLER
R-20
HEADER WRAP AND AIR-SEALING
I-BEAM
DROP CEILING
HEADER
ACCESS FOR
INSULATION
HOUSE WRAP
AIR
BARRIER
DRYWALL AND GAS PROOFING

Simplified Beam – Header detail for rooms above porch

Most builders use a complex system of beams and headers to carry dormers above. A Building Canada approach consisted of double joists at each end and all joists bearing on either the porch beam or front garage wall. This eliminated all headers and joist hangers, which, traditionally, have been a source of air leakage or floor squeaks. Solid blocking between the joists was custom cut from I-joist material. This consisted of cutting back top and bottom cords of the blocking in order to match the profile of the joist on either side. As well, house wrap was used to further air seal the cavity. This cavity was filled with blown-in cellulose insulation. Past research conducted by Builder E has shown this to be an extremely effective air barrier. Builder E suggested it was far more cost efficient than urethane foam. The lumber supplier should develop a solid blocking system to match the profile of their patented engineered joists.

Figure 5.29


Figure 5.30

Simplified Framing to Accommodate Mechanical, Electrical and Plumbing

As previously discussed, the floor layout was greatly simplified by using three sets of engineered floor joists, running front to back. The engineered joist system was selected because of the unique "strong back" design which consists of three windows near the centre of the joist. These windows were used to the builder's advantage for easy access and installation of the domestic water, drains, mechanical, electrical, telephone and central vac. runs. The windows pointing to the rear of the house were used for plumbing installations, the center and larger windows for the mechanical, and the windows facing the front of the house for household wiring. This window system greatly reduced man-hours as no drilling holes through the joist were required. The only time (save one exception) a trade had to drill a hole was through studs or between floors.

Figure 5.32

Figure 5.33

Figure 5.31

Figure 5.34

Add a 2X10 Beam, Dropped Below Front Bay Windows

The first floor framing consisted of rows of the engineered joists, most at 19.2 inches o.c. The exception to this was at the front of the house where the spacing was 16 inches o.c. at the foundation bump outs for the bay windows. Two problems were created: 1) four additional Engineered Joists and 2) increased waste of plywood subfloor due to changes in spacing. This problem could be remedied by forming beam pockets into the foundation wall and installing double 2X10's. This would eliminate the need for changes in joist spacing.

Figure 5.35

Insulated Headers

Headers, particularly those used for the dormers, were insulated with expanded polystyrene (EPS). The double layer of EPS that was used on the outside perimeter was taken from waste material from wall construction. This system also served to reduce air infiltration resulting from the void between the top and bottom cords of the joists. The wood supplier was challenged to develop an insulated header with the insulation manufacturer.

Figure 5.36

Insulated Double Joist System

A potential area of air leakage was the void between the top and bottom plates in double joists (figure 5.37). This problem was solved by inserting a short 2X8 and a single layer of EPS. Further sealing could be accomplished with one part expandable poly-urethane foam. A need for an insulated joist was identified which could be delivered on-site complete with insulation and securely fastened with gussets, ready to trim to length by the framers.

Figure 5.37

Figure 5.38

Use of Squash blocks

The primary purpose of squash blocks is to increase the bearing resistance of rim joists. On the first floor, (figure 5.39), squash blocks were used at approximately 24 inches o.c. On the second subfloor, a double joist was used instead on the outside walls (figure 5.40). This resulted in a number of problems: 1) difficulty in insulating, 2) potential air infiltration, and 3) running electric wires. It also increased the number of joist on the second floor by six. Squash blocks are the recommended alternative in all situations.

Figure 5.39

Figure 5.40

Framing Contractor Feedback
The carpentry trade made the following comments about the framing changes:


Figure 5.41

Subfloor
1. Engineered joists require greater care and more time to install than dimensional lumber.
2. The front to back joist layout was unique and saved time.
3. The second subfloor joist from outside wall to porch beam was a definite improvement and time saver.
4. Eliminating changes in joist direction made plywood installation easier and more efficient.

Walls
1. The elimination of dormer lintels was convenient, however, not a great advantage to the framer.
2. The elimination of bearing partitions and associated drop beams and lintels saved a great deal of time, energy and materials.

Roof
1. Using trusses on the dormers greatly simplified truss installation and provided consistency in roof pitches.
2. Use of mono trusses between the dormers also simplified truss installation.
3. The oversized foundation and the resultant roof complications negated any positive effect of the truss system.
4. An extended heel on the mono trusses would probably solve many problems in truss alignment.

Framing Costing Considerations

The main cost savings of the framing (not including trusses) resulted from an advanced engineered floor system and layout. Items contributing to cost savings were as follows:

1. Elimination of steel I-beam in basement.
2. Elimination of flush beams.
3. Elimination of LVLs.
4. Elimination of drop beams over archways on main floor.
5. Increased stud spacing on some walls from 16 inches o.c. to 19.2 o.c. due to the elimination of some bearing partitions.
6. Elimination of lintels in the dormers.
7. Elimination of header / beam combinations for dormers above porch and garage.
8. Replace tall wall with conventional framing on standard spacing, to increase ease of construction and insulation.

The engineered floor represented a $950.00 material upgrade, but with the elimination of the items cited above, the total floor wall framing cost was $200.00 less than conventional framing alternative. This included factoring in two extra courses of bricks due to increased joist size.

There was an increased cost in roof framing mainly due to the cost of dormer trusses. With additional refinement, this could represent a potential labour savings. This labour savings is one that probably would not translate into cost savings to the builder in most cases since piece-work framing contracts dominate the GTA market. The framers did indicate that trusses are a preferred alternative. As margins improve for framers this may be reflected in pricing.

Figure 5.42

Mechanical System

The Heating System: Rationale
Builder E chose to install a high velocity forced air heating system. This system heats water to 180^{o}F with a wall hung instantaneous domestic hot water boiler and using an air handler / heat exchange unit which drives high velocity air through 5, 6 and 8 inch trunk lines and 2-inch insulated, flexible lines. The system takes advantage of the windows in the strong back joist for duct runs. With a window height is 4.25 inches it easily accommodates the 2-inch pipe and 2 inches of insulation (4 inches total diameter).

Figure 5.43

The Air Handler
The air handler consists of a core heat exchanger, a plenum, a return air intake and a 3-speed / variable speed fan.
The air handler utilizes water preheated to 180^{o}F to heat the air for the high velocity system. The high-speed operation of the fan is reserved for air conditioning, and the lower speed for heating. The heating contractor suggested the high velocity A/C system would improve cooling efficiently particularly on the second floor.

Figure 5.44

The HRV
Builder E chose to investigate another innovation, a static HRV. This HRV consists of a medium efficiency heat exchange core, 8-inch fresh air intake, 8-inch exhaust and a direct connection to the cold air return. Cold air is pulled through the core, preheated by the return air, and then cycled through the air handler. The return air is exhausted to the outside. The HRV uses the energy of the air handler fan system to move air through its core. Since there is always warm return air running through the core, core icing is not an issue. The one feature that should be added to this system is a timer for air cycling. The static HRV may provide significant savings in cost over more conventional systems.

Figure 5.45

Domestic Hot Water
The instantaneous domestic hot water boiler is a gas-fired, non-condensing boiler, operating at a peak efficiency of 85%. Domestic hot water leaves the boiler at 130^{o}F and is part of a split domestic water / heating system. When the boiler is in heating mode, and hot water is required, water always takes priority over heat. This instant on, hot water on demand system eliminates the need for a hot water heater, improves on conventional domestic hot water heating efficiencies and lowers stand-by loses.

Figure 5.47

Figure 5.46

Heat Runs: Installation, Flexible Ducts
The high velocity ducts maximum run from trunk line to the heat outlet is 15 feet. All joints were taped with aluminum tape to reduce heat loss.


Figure 5.48


Figure 5.49

Trunk Lines
Five, six and eight inch trunk lines were used to distribute the air to the 2 inch flexible heat runs. These trunk lines were hidden beside beams in the basement and in chases on the main floor. All reducers and adapters were taped with aluminum tape to reduce air leakage. Trunk lines passing through the windows of the joist system were 5-inch round ducts, shaped to an oval that would pass through the 4.25 opening. The main problem with running a trunk through the joist windows was that the maximum trunk length is 36 inches. This meant that a trunk line 8 feet in length could only be installed through the windows with 3 individual pieces. This problem suggests a need for vertical trunk lines.


Figure 5.50


Figure 5.51

Cold Air Returns

Reducing the length of runs for the cold air returns was achieved by allowing the mechanical contractor to choose the location of the air handler. Cold air returns were tucked in tightly beside I-beams in the basement and never extended below the I-beam depth (8 inches). Returns were run to the floors above through ducts in either wall cavities or chases with a combination of squared or round adaptors and reducers. All joints were taped with aluminum tape. (Figures 5.52, 5.53, 5.54)

Figure 5.52

Figure 5.53

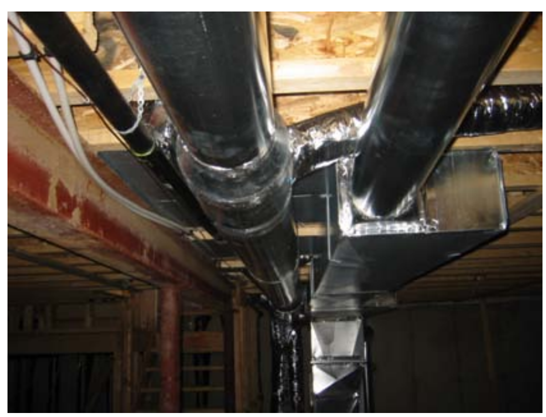


Figure 5.54

Diffusers
The diffusers are the high velocity equivalent of the standard register. These are 4-inch diameter plates with flow adjusters. A special tool is used to adjust the flow and balance the heat. The high velocity system requires 50% more heat runs than a traditional forced air system. All joints to the diffusers were taped. All connections were sealed with aluminum tape to prevent leakage of the heated air.


Figure 5.55

On the main and second floors, all heat outlets were sealed with special caps to prevent debris from getting into the system. The caps in the bathroom areas where floor tiles will be installed would be painted bright orange or extended and cut off later, so that the tile setter does not cover them with mortar when laying down the scratch coat.


Figure 5.56


Figure 5.57


Figure 5.58

Mechanical Contractor Feedback
The mechanical contractor was very pleased with the ease of installation, neatness and reduced material cost of the cold air returns. The flexible ducts were very easy to install. Common complaints were the need for sealing all joints with aluminum tape, and running short lengths of trunk line through the joist windows.

The installation of the HV system took slightly less time than a conventional forced air system. There were, however, increased material costs for the 2-inch insulated heat runs and slightly less materials costs for reduced material in the cold air returns. The heating contractor did indicate that the cost of installation (material plus labour) was the same as a conventional forced air system. This includes reducing costs by $600.00 - $800.00 through the elimination of the furnace.

The instantaneous domestic hot water boiler adds an additional $2600.00 to the cost of the heating system, however, they are available to be leased for $28.35 a month. This lease would be carried by the homeowner, and include a full 15 year parts and labour warranty. The cost of this lease would also be offset by the elimination of water heater rental charges, making the actual lease payments less than $10.00 per month. Leasing the boiler makes the most sense as then the system can be sold as an upgraded standard, rather than an extra. Any area of the house is now "radiant floor ready" allowing the builder to sell

Plumbing

Plastic Domestic Water Lines: Rationale
The decision to use plastic domestic water lines was based on manufacturer feedback that this decision would result in substantial financial savings. The team chose to use plastic plumbing lines with brass fittings. Due to the advance floor framing system, the only time that the plumbers had to drill a hole was to run the lines between the floors. See figure 5.59.

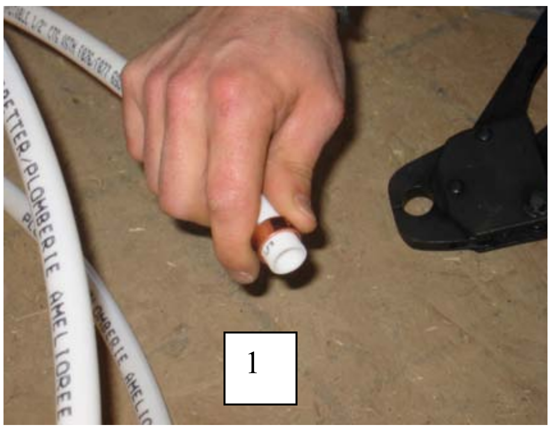
Figure 5.59

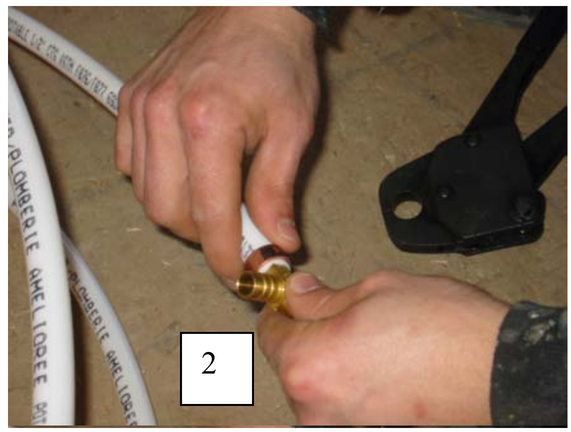
Installation and Fittings
All fittings were brass and lines were fastened with special clamps provided, as illustrated in figure 5.60.

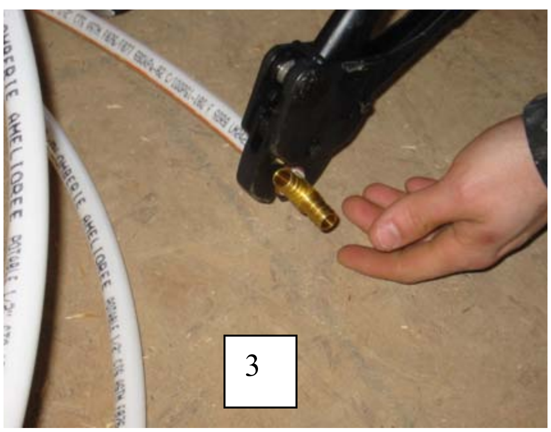
Figure 5.60

The pictures below illustrate the ease with which the fittings were installed:

1. Brass ring slipped over plastic pipe.
2. Brass fitting inserted into plastic pipe.
3. Crimper fitted and locked over brass ring.
4. Brass ring crimped; connection sealed.







Brass fittings were available as couplings, right angle, and Ts. This connection process is far more efficient than soldering.

Drains

There were no major changes to the drain system of the house. The strong back, engineered joists allowed for quicker installation. There was one instance when the plumber had to drill through a joist to install the drain. This required a phone call to the manufacturer to get the exact location and diameter of the hole. Whenever possible, all drains were run parallel to the joists.

Figure 5.62

Figure 5.61

Figure 5.63

Special Considerations and Costing

The plumbers who installed the system were very excited about the ease with which it was installed. Rough-in, basement and pressure test were all completed within 6 hours. The plumbers did comment that a two-man team is not required for the installation of plastic pipe. It should be noted that the plumbers did not go into this installation "cold", but they received training from the plastic plumbing manufacturer.

Domestic water line installation time was reduced by 75%. A full 1.5 days. This reduces the builder's production schedule and it would allow a contractor to increase productivity by almost 300%. This would also give the contractor a strategic advantage when bidding on jobs if he chose to specify plastic domestic water lines.

The foreman did mention concerns that his men would make less money. The use of plastic for domestic water lines is an issue that has not been totally resolved in contract negotiations between the plumbers' union and management.

Electrical

Self- Sealing Boxes

Self-sealing electrical boxes were used on all outside walls and ceilings. This type of electrical box greatly impacts the air-tightness of the house and is often recommended if the builder wishes to achieve R-2000 standards.

Figure 5.64

Figure 5.65

Installation

The electrical wires were installed through the engineered joist, using the windows provided. This system reduced considerable time in the actual wiring stage, however, required more wire because the electricians could not run the line diagonally; having to remain in the window openings.

Figure 5.66

Contractor Feedback and Special Considerations

The Electrical Contractor would not commit to any price reductions, or even suggest that the self-sealing boxes could be thrown-in as a standard, as a result of reduced man-hours. The electricians liked the system; however, they are not the ones paying for the extra wire (from using the joist windows only). More trials need be run in this area with different models as well as different contractors in order to get an accurate assessment in this trade area.

Other Changes

The Stove Fan Vent

Builder E, like most builders in the Greater Toronto Area, has traditionally strapped walls that contain a 6" vent, such as a stove hood vent. Due to space restraints and the problems associated with a tight distance between the counter width and the location of the door, it became necessary to modify the traditional 6" duct installation. The Build Canada Team suggested to the contractor that the round vent be adapted to an in-wall box of equal volume, so that the exhaust (in CFM's) would remain unaffected. This required about the same amount of time, saved the rough-in carpenters a reasonable amount of time and saved the builder strapping materials building out the 2X4 wall to the equivalent of a 2X6 wall.

Figure 5.67

Figure 5.68

The Shower Stall

The shower-pan membrane was identified by Builder E as one of the top ten customer service problem areas. Builder E has written into its scopes of work that the drywallers should cut a piece of drywall and install it over the drain to prevent puncturing from other trades. The problem with this system is that it requires increased monitoring and vigilance from the site supervisory staff. An easier solution might be to install the membrane at a later point in the construction schedule. Builder E will work on this problem in the future.

Figure 5.69

Knots Bleeding Through Exterior

Builder E uses white pine for ornamental trim. The wood, by nature, contains many knots. Builder E has tried numerous techniques to halt the bleeding-through (the paint) of the knots. A possible solution presented at the Build Canada meeting was to use alternative materials such as "Hardy Plank" or exterior grade MDF. A pricing investigation is currently underway.

Figure 5.70

Low-E windows

The use of Low-E windows was considered a priority for the planning team, but for the builder, it represented a 15% price increase above the regular window. Much investigation and negotiating took place to reduce this cost (with the promises of a quantity purchase). None of the window manufacturers contacted would move off a proposed of approximately $750.00 to the price of the house. A compromise solution was found when a Cambridge, ON window manufacturer quoted a 7% increase for Low-E windows ONLY. These windows would not be argon-filled. This may be a worthwhile trade-off to consider.

Figure 5.71

Figure 5.72

Deck Attachment

The deck attachment was seen by the Build Canada Team as a potential problem area, possibility resulting in deck detachment. This remains an area of concern.

Figure 5.73

Dents in the Front Door
This was another item identified by Builder E as a constant source of service. The trades bang the door with tools, lumber, etc., and the site staff must repair. The painting contractor must use auto-body filler and re-paint in order to repair the damages. A special guard for the door was investigated. It consisted of a Styrofoam bump guard, specially affixed to the door. Two problems are associated with this solution:

1. $15.00 is excessive, since it exceeds the cost of repair and,
2. Bumper guards were used in the past and they actually increased door damage due to over-confidence in the dent resistant guards with the trades becoming sloppier.

This problem remains unresolved.

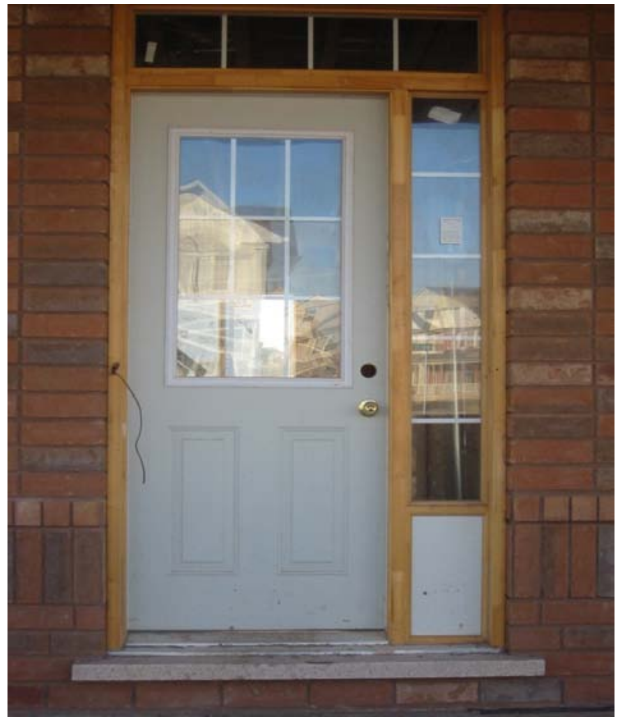


Figure 5.74

Steel Columns and Thermal Bridging
The location of the steel support columns in the outside walls has been identified as a major source of thermal bridging. Without completely re-designing the house, one solution might be to cover them with architectural features such as box-outs. This example arose in the demonstration house where, if the decorative architectural box which hides the dropped LVL was moved 8 inches to the front of the house, the thermal bridging problem would be resolved.

Figure 5.75

Window Foam Installation

Proper installation of expandable urethane foam is critical to not only the air tightness of the building, but, also, to the proper operation of the window. Integral to good installation of foam is the use of a good quality foam gun. Foam must be applied using the tip of the foam gun, inserted well into the space between the window and the frame. Too much foam will cause the window frame to bow, as will foam not applied towards the centre of the space. Window installation, as well, greatly impacts air infiltration when done incorrectly. Figure 5.76 shows the plywood shim installed flush with the inside of the wall. This leaves inadequate room for air sealing with either foam or caulking. The double shim, when improperly installed, will leave large holes that cause air leakage.

Figure 5.76

Air Tightness

Air Tightness Considerations

The Builder E Building Canada Home went through a process of value engineering and re-designing to realize airtightness improvements are expected. Unfortunately, a blower door test is still months away as Builder E has not put the house on the market, yet. Based on previous research conducted by Builder E and its partners it can be inferred that the construction of the garage drop ceiling is considerably more airtight than Builder E's conventional construction.

Figure 5.77

5.5 Builder E Summary

During the Building Canada process the company underwent significant corporate restructuring with a loss of the individuals committed to the process. As a result, it is unclear whether Builder E will commit to additional Building Canada homes.

The final Building Canada house was much more daring in attempting to demonstrate new construction technologies than had been anticipated by the Building Canada team. Builder E's project manager in some cases attempted to demonstrate new technologies that have not been mainstreamed within the residential market, pushing the limits of Building Canada objectives to optimize construction. As such, it's not clear to what extent Builder E will embrace the initiative as a whole. In future the team would recommend a much tighter control over the new technologies demonstrated.

6.0 Assessment of Feasibility of Adopting Building America for the Canadian Market

Building America enjoys very significant US federal government funding and as such is an ambitious, far-reaching program. It is unclear whether a Building Canada initiative could enjoy a similar level of support. Building Canada, by necessity, will likely need to differ from its US counterpart. It is unclear whether the level of co-ordination and interaction enjoyed by Building America will ever be possible in the sparser Canadian market. Building Canada will need to evolve regionally, providing customized solutions to Canada's production builders.

The level of interest expressed by builders appears extraordinarily high. A number of builders who have completed the pilot phase have expressed interest in expanding the initiative to a larger number of homes. It is essential to note the importance of the trust relationship that develops between the builder and consulting team. The trust relationship should include senior company executives preferably up to the president's level. The Building Canada consulting team is often privy to private and confidential data including pricing and defect information that if made public could be detrimental to the builder's business. The trust relationship is also essential as the company's culture evolves as it embraces Building Canada.

Profitability and financial self-sufficiency is not contemplated for, at best, three years. The effort associated with the Building Canada initiative for any builder is diffuse and long lasting. The Building Canada team needs to be involved at the earliest possible point in the product development cycle. This implies that from concept to construction and evaluation, it is not unreasonable for the initiative to take 18 months for any one builder. It is expected that self-sufficiency and viability should be possible after two or three product cycles.

Building Canada is clearly not tailored for the small builder. In fact, it would appear that the benefits of Building Canada may be largely lost on builders constructing fewer than 100 homes per year.

6.1 Recommendations

The next steps for Building Canada would involve developing a fuller understanding of the market for Building Canada and expanding the initiative to other parts of the country. To this end a number of steps should be considered:

1. **Develop a map of all production builders across Canada.** The map would list production builders from across Canada, establish the volume for each, rate the level of influence each builder holds within the builder community and each region, and summarize the nature of the current construction for each builder. From this data a complete database of the top 100 large production builders across Canada would be developed.

2. **Identify 30 key builders interested in participating in Building Canada.** Using the builder database interested builders would be identified, as would the key areas or issues that these builders would like to concentrate on. Builders for participation in the next phase of Building Canada would be selected.

3. **Establish and train regional Building Canada teams**. Individuals with the necessary combination of skills and expertise need to be identified to form teams in different regions of the country. A database of interested consultants from across the country can be developed for future national deployment phases. Teams will need to be trained.

4. **Deploy the Building Canada Teams.** In executing the Building Canada process it will be necessary to:

- identify the most appropriate champions within each builder organization;
- identify the most appropriate key contact for each builder within the regional Building Canada team;
- steer the Building Canada process through the organization of 30 of Canada's 100 largest production builders; support the key decision maker within each of the 30 key builders to understand and promote Building Canada within the organization; support co-ordination and management of the Building Canada Process.

5. **Benchmark the performance of houses before and after Building Canada upgrades**. Identify and document all Building Canada upgrades, including: description of each alternative for each builder, summary of the alternatives selected for construction by each builder, summary of the costs, benefits and specific issues relating to each selected alternative, specific construction issues arising from adoption of selected alternatives, and degree of success in adoption by each production builder.

6. **Secure commitment**. A commitment should be secured from participating builders to incorporate successful upgrades in their standard product and to reinvest savings achieved into energy efficiency upgrades.

7. **Revisit Builders.** Each participating builder should be revisited within one year to determine the level of Building Canada upgrade adoption.