INNOVATIVE BUILDINGS

Southfield Solar Model Home -Guelph, Ont.

Figure 1 – The Southfield home in Guelph, Ontario modeled passive solar design for free heating, cooling and lighting; an active solar domestic water heating system; a grid-tied photovoltaic (solar electric) system; and energy-wise landscaping. One year of monitoring revealed the solar systems produced comparable quantities of energy as conventional energy upgrades, for comparable costs.

In the fall of 2001, Thomasfield Homes and Nexus Solar developed the Southfield Solar Model Home in Guelph, Ont. to showcase cleaner energy alternatives in a conventional subdivision. The systems demonstrated were:

- solar design* (*provide hyperlink 1)
- R2000 construction,
- solar hot water,* (*provide hyperlink 2).
- tankless water heater,
- photovoltaics,* (*provide hyperlink 3).
- high efficiency furnace and equipment, and
- energy-wise landscaping*.(*provide hyperlink 4)

Thomasfield, Nexus Solar, Natural Resources Canada (NRCan) and Canada Mortgage and Housing Corporation (CMHC) monitored the Southfield and a conventional house next door for a year. The monitoring compared the solar upgrades with the conventional upgrades. Energy savings, greenhouse gas reductions, net cost savings and factoring in the additional cost associated with owning the system were estimated for the houses as if occupied by an average Canadian family of four.

Key findings include:

Southfield's solar energy systems were competitive with conventional energy upgrades.

The solar energy systems were competitive with conventional upgrades in both total useful annual energy production and net cost of solar energy.

Only two of six energy upgrades evaluated saved more than they cost to finance.

Passive solar space heating design and a high efficiency furnace with an electronically-controlled motor saved more money in the first year than their combined mortgage and maintenance costs, making them cheaper to own than not. The other upgrades - tankless water heater, solar water heater, grid-tied solar electricity (photovoltaic) system and R-2000 construction - did not save enough money in energy bills to finance the cost of upgrade.

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High energy-saving upgrades do not necessarily save money, while other systems that save small amounts of energy can produce worthwhile economic savings.

A number of factors affect the productivity and net affordability of energy upgrades besides purchase cost, including fuel use, maintenance and repair costs, and synergies and redundancy among combined measures.

Maintenance is a necessary and significant expense that gives low-maintenance systems many advantages.

The maintenance requirements of some advanced technologies can reduce their overall attractiveness and affordability. Solar systems like the passive solar design, energy-wise landscaping and grid-tied solar power, in contrast to many mechanical systems, are typically benign and therefore not just environmental friendly, but also easy to operate, quiet, and maintenance free.

Combining energy efficiency with renewable (solar) energy met the majority of space and water heating requirements.

Solar design with the R-2000[1] system provided 53 percent of the space heating load. The solar hot water system provided 59 percent of the energy need for water heating[2] where a demand water heater (saving on standby losses) is used. Thus the solar systems reduced (quite unexpectedly in a subdivision environment) natural gas to role of supplementary energy source for both space and water heating.

Solar systems improve energy supply and security.

Most energy systems use carbon-based fuels, while solar systems supply independent reserves of energy at a fairly predictable price and quantity. Although solar design requires solar access and moderately sunny weather, less than ideal conditions on both counts in the Southfield demonstrate that it would not be difficult to achieve significant reductions as demonstrated here.

The solar domestic water heating (SDWH) system contributed as much towards water heating as R-2000 did to space heating, both an impressive 39%. SDWH contributed more than the tankless water heater, which contributed 29 percent, thus **the renewable energy systems, particularly solar space and solar domestic water heating, saved as much energy as as effective as traditional energy-efficiency technologies**.

Though the grid-tied solar-electric (photovoltaic) system made a minor contribution of 7% toward electricity loads, its contribution towards greenhouse gas (GHG) emissions is greater.

This kind of system probably cut GHG more than the gross data reveal, since productivity of solar power systems directly offsets carbon-rich, peak power generation (i.e. required during the afternoon).

Passive solar design is an elegant and simple solution to rising energy and housing costs.

Employing passive solar energy is both inexpensive and effective in reducing space heating fuel requirements and resulting GHG emissions. Passive solar design provided 28 percent of the space-heating requirements, reducing GHG emissions by nearly one tonne (998 kg) even though the Southfield is not ideally oriented (front faces southeast). Even though ideal orientation is obviously non-essential, some south exposure is. Hence developers, builders, city planners and municipal leaders should know the importance of strategic measures such as street and façade orientation in enabling homeowners to reduce their home consumption of fossil-fuel energy.

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[1] Link to R2000n description.

[2] After removing standby losses to keep the water tank always hot.

Purpose of the Southfield Solar Model Home

The Southfield Solar Model Home was built to raise awareness of available solar technologies. Homebuyers and homebuilders are unfamiliar with solar energy, even though they have a long history in the field and have been endorsed by government agencies for years (e.g., hyperlink to NRCan's Homeowners' Guide to Solar Domestic Water Heating Systems and to RETScreen). Lack of personal experience with their operation and capabilities, and costs and benefits, discourages many homebuilders and buyers from incorporating them.

Familiarizing the builder's trades and maintenance services crews with new, advanced systems was also key to success of the project.

Since preliminary modelling had been done to assist in the design process, the project also presented an opportunity to verify performance simulation modelling tools, including *Hot2000* and *RETScreen*, for their practical ability to accurately predict energy savings.

Finally, although not originally intended, since the R2000, and demand water heating systems were also featured in the house, direct comparisons between solar and conventional space and water heating systems were possible.

Evaluation procedure

NRCan and CMHC agreed to assist the Thomasfield-Nexus Solar team to monitor the Southfield and the Argyle house next door, for comparison. The two show homes had about the same heated volume however the Argyle did not have the advanced and solar energy upgrades.

The Argyle and the Southfield were initially unoccupied. Hot water was drawn to simulate occupancy by a family of four and an onsite computer measured inside and outside environmental conditions. Electricity demand was based on average figures provided by Guelph Hydro at the time.

The effect of landscaping was not measured, since its benefits could not be quantified until the shade trees are established. However, a rough estimate for solar landscaping made by Natural Resources Canada suggested that, had the Southfield been mechanically air conditioned, at least half the space cooling load would be offset by shade trees located close to the house and pruned to a high crown. [hotlink 4 Energy Landscaping]

Indoor conditions were difficult to control during the summer in the model homes, and therefore the results unfortunately exclude contributions of passive architectural design to cooling, lighting and ventilation loads; only the space heating contribution of passive solar design was determined.

The data was analyzed and is presented as if each of the systems were installed as individual system upgrades. This is the most useful way to present the information, since most homebuyers would be more likely to buy one, rather than all, available upgrade systems. This presentation also permits comparison of individual systems (specifically solar water versus demand water heating and passive solar design with R2000 for space heating). Costs were presented as if they were part of the home mortgage package, requiring 25% down payment at the time of the home purchase. The increase in monthly mortgage payments attributed to each of the measures is reported beside the energy savings generated.

The researchers used a natural gas price of 37 cents per m^3 and an electricity price of 8.45 cents per kWh. *Near the end of 2006, the natural gas' per cubic metre charge (after flat monthly rate of $14.00) is $0.4940. The per kWh charge for electricity (after flat monthly rate of $12.74) is either $0.058 if less than 600kWh is used in a 30 day period (1,000 in winter), or $0.067 if more than 600 kWh is used in a 30 day period (over 1,000 kWh in winter.*

Results - System performance

1. Solar systems

The researchers evaluated three solar systems:

1. passive solar building design
2. solar domestic water heating also tied to basement in-floor space heating
3. a grid-tied solar electric or photovoltaic (PV) system.

Passive solar design

Passive solar architecture (hyperlink) optimizes building design to take better advantage of free daylight and heating, ventilation, and cooling opportunities. Good passive climatic design harnesses solar radiation to minimize fuel consumption for heating in winter, cooling in summer and for daylighting throughout the year. Figure 2 shows the Southfield floor plan and passive design measures.

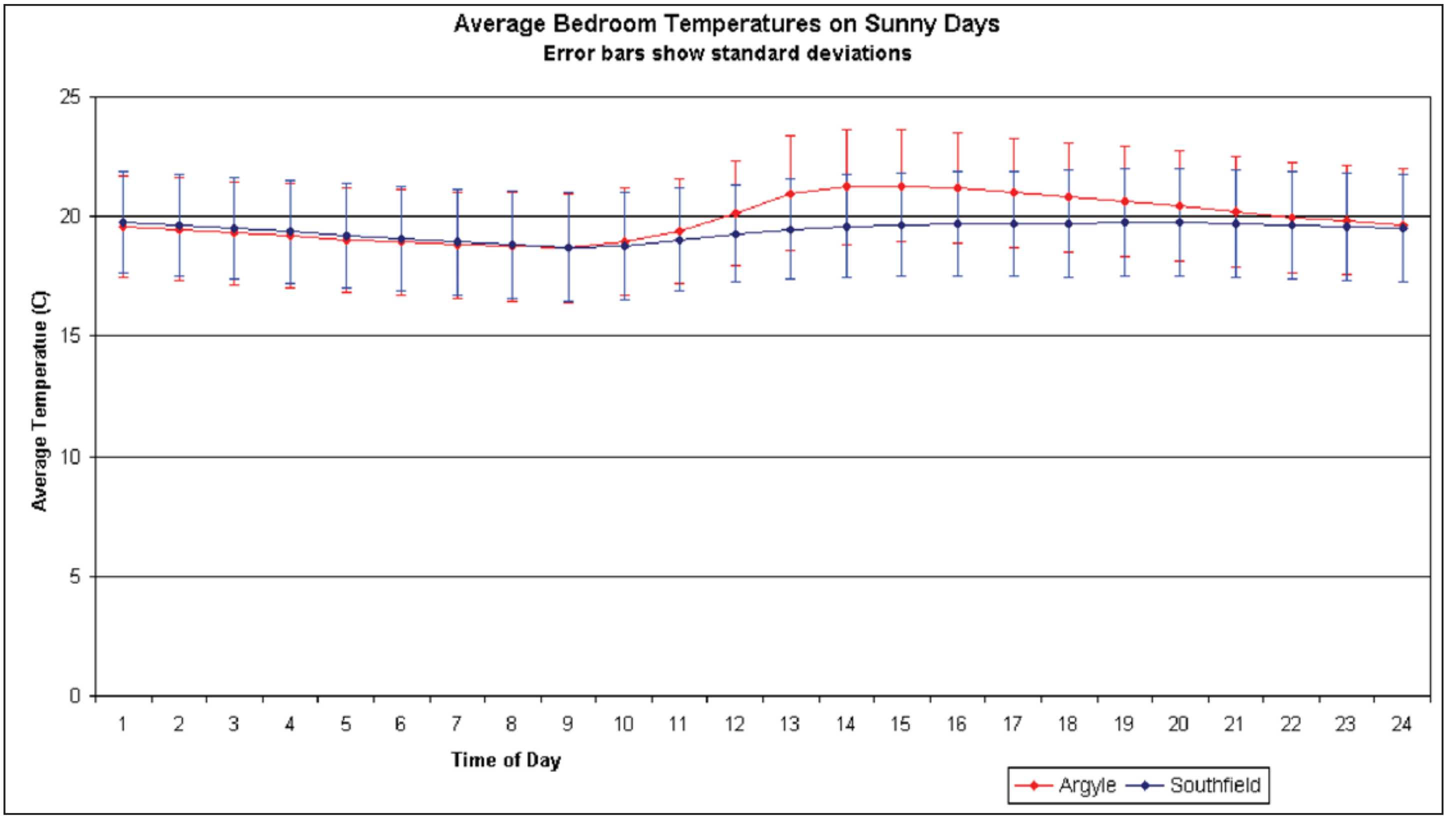

Figure 2 – Design for passive solar heating includes not only solar heat gain, but also heat storage and controlled heat withdrawal. Many new homes suffer from daytime overheating because airtight conditions can keep heat trapped in rooms that lack sufficient mass to prevent excessive temperature variations. Inclusion of extra thermal mass, such as extra layers of drywall or ceramic floors, absorbs excessive daytime heat and holds it (like a battery) until the cooler evening when the heat is slowly released. The red line shows that an additional layer of drywall helped to keep daytime room temperature of one of the Southfield second-storey, south-facing bedrooms two degrees Celsius cooler in the afternoon than in the comparable room in the house next door

Passive solar design contributed 28% of the space heating requirement. Three simple, passive solar-heating measures (better thermal characteristics of the windows, extra window on the south side of the house, and a second layer of drywall added to interior sunlit walls) contributed probably most of this 28 percent, around 16 percent (equal to $193). These passive solar upgrades cost only $662, about one quarter of the total solar design upgrade cost. (The rest is for free cooling, lighting and ventilation, benefits not measured in this study.

The study results show that passive solar design was easy to maintain and would be affordable for most households. Passive solar design should last for the lifetime of the building with little maintenance or replacement. Even the Argyle house obtained 22 percent of its space heating needs from the sun. Though its orientation was similar, it has fewer surface windows and higher space heat load.

Even though the Southfield site and building were not ideally oriented, solar radiation provided over one-quarter of the space-heating load at 28 percent. By adding passive solar features to the mortgage payments, it costs less to live in the home with the passive solar upgrades than in the same home without.

Solar domestic water heating

The Southfield solar domestic water heating (SDWH) (hyperlink2) system provided 39 percent of the domestic hot water needs of an average Canadian family of four including one teenager. System productivity depends heavily on the weather. On sunny days, practically all of the hot water load was met by the solar system. For example, on Oct. 1, 2002, well past the autumn equinox, 94 percent of the hot water load was met by sunshine (see Figure 3).

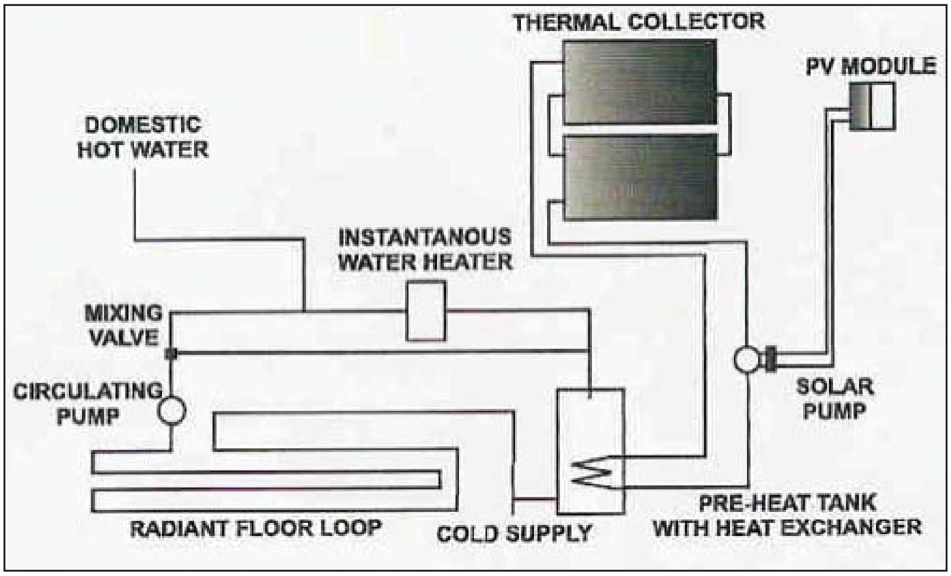

Figure 3 – Schematic of the solar domestic water heating (SDWH) system in the Southfield. This system contributed as much towards hot water heating as the R-2000 system did for space heating (39%). Combined with a tankless water heater, the system enabled solar radiation to provide the majority (59%) of the water heating load for an average Canadian family of four, including one teenager.

The 39 percent average annual contribution is low compared to RET Screens prediction of 45 percent. This is an acceptable degree of variation yet mostly can be attributed to the months of May, June, July and August 2003 (months when maximum productivity can be expected) being all cloudier than normal.

The Southfield basement also features hydronic (in-floor water) heating, so spare heat available in spring or fall could be diverted into that floor. Hot-2000 predicted that the SDWH would contribute approximately four percent of total space-heating load. Measurements did not exceed expectations, since the two-panel system size, because of its location on a flat roof, is intended for summer load. Whenever hot water draw is low, the system can supply more heat for space heating.

The combination of the SDWH system with the tankless water heater avoids the standby losses of a hot water tank so that the solar water heater can be the principal water heating system in a home (59 percent), with gas providing backup (41 percent).

Photovoltaic (PV) electricity

The PV system (hyperlink) provided 555 kWh - six percent - of the 9,926 kWh electricity required by an average Guelph household per year. The results confirm that first efforts to reduce electricity costs ideally should by reducing energy consumption. Energy-efficient appliances, along with a conservation lifestyle, lead the way to lower household power use. When the total electrical consumption is reduced, renewable energy systems such as solar then will handle larger fractions of the load.

The PV orientation of 126 degrees west of south (SW) on a roof pitched at 12 vertically: 8 horizontally is sub-optional for maximizing total annual electricity production. However, the orientation and pitch may be optimal for contributing to peak electricity loads in the summer. It is during sunny summer afternoons that high air conditioning demands are coincident with peak PV electricity production. In southern Ontario, coal-fired generating plants typically handle these peak summer loads and thus this PV orientation will offset proportionately more than 6 percent GHG emissions.

Although a PV system is a fairly expensive upgrade, it can be considered rather than an energy system to be a home luxury item like any other, in which case its benefits are no less than those of a hot tub or marble floor. If 75 percent of a PV system is mortgaged with the house, the net monthly cost of the upgrade (mortgage and maintenance premium less energy savings) is similar to many ordinary household expenses, like cable TV.

Mainstream energy upgrades

The mainstream advanced energy upgrades principally reduce household energy use by improving the energy efficiency of mechanical equipment, such as better fans, motors, pumps, or increased insulation. The Southfield project evaluated:

1. a high-efficiency furnace with upgraded dual-phase, or electronically commutated (ECM) motor
2. a tankless water heater
3. the R-2000 standard.

High-efficiency furnace with ECM motor

The high-efficiency furnace saves energy in two ways - it burns gas more efficiently than a medium-efficiency furnace and its electronically commutated motor (ECM) cuts electricity consumption by variable speed motors that deliver heat in steps as-needed, rather than either *off* or *maximum* power.

The furnace's annual natural gas saving was $158. The variable-speed motor saved another $44, representing 519 kWh of electricity. Maintenance costs were the same as a regular furnace.

The dual-stage, high-efficiency furnace with an ECM is a relatively inexpensive upgrade ($1,600) and cost-effective. Savings of $202 in the first year of operation exceed the mortgage premium of $112 (i.e., on 75 percent of the $1,600 system purchase cost).

Tankless water heater

Demand water heaters, also known as tankless or instantaneous water heaters, reduce energy consumption by heating water as it is used rather than keeping a large tank of water hot all the time. In addition to eliminating standby losses, some (like the one in the Southfield) also save energy because they use electronic ignition instead of burning a pilot light continuously.

The Southfield demand water heater produced enough heat to reduce gas consumption by 29 percent. However, there were problems with the unit. Within a few months of use, Guelph's hard water had left residue in the unit, which caused a valve to blow, and hot water flowed until it was discovered. The mechanical contractor now recommends buying a water softener for a demand water heater. This purchase, along with regular maintenance, reduces the technology's savings and environmental benefit.

Tankless systems are recommended for households with either small or large hot water loads. In small households where water use is infrequent, standby losses associated with keeping water in the tank always hot (whether hot water is used or not) are proportionately large. In large families, or households using hot water for both domestic uses and space heating, a demand water heater used in combination with another hot water system (solar or water heater tank) can offer better efficiency than ordinary tank systems.

R-2000 standard

R-2000 construction consists of airtight and well-insulated construction including advanced windows, extra insulation, and installation care in applying sealants and avoiding punctures. Being airtight, R-2000 houses require mechanical ventilation, usually in the form of a heat recovery ventilator (HRV). HRVs pre-heat cold air entering the furnace with exiting, warm exhaust air.

R-2000 houses are individually assessed and certified. The quality assured by R-2000 certification might be considered a prerequisite for a passive solar home, since smaller heating loads let solar elements contribute larger fractions of the total heating load.

The cost of an R-2000 upgrade varies depending on location, as fees and level of accepted practice vary. The Southfield's R-2000 upgrade cost $12,999, on the high side because of measures such as basement floor insulation (a comparatively costly way to achieve the R-2000 Standard). The average cost for an R-2000 upgrade is less, and a more typical cost of $8,500 was used in the cost analysis.

The R-2000 upgrade saved $436 in fuel costs over one year. The annual mortgage premium was $594. Therefore, the net savings is negative $242, or in other words, it cost more to own the R-2000 package than it does a regular house, at least at a gas price of 37 cents/m^3 and mortgage interest rate of 5.5 percent.

R-2000 homes not only save energy, but are usually better built and more comfortable. However, the systems have to be operating properly to produce the energy savings. There were problems with the HRV in this house. During the course of the research year, whole-house gas consumption sometimes correlated poorly with natural gas bills, and so twice during the year of research and again two months after the end of the study, the HRV was checked. Twice it was found to be out of balance. At one point, one of the dampers was not working, which eliminated any heat recovery.

It is not known whether this condition existed throughout the monitoring period, but if it was, theoretically up to 312 m^3 of gas (about $115) would have been consumed unnecessarily. Since heat recovery only occurs when the HRV is functioning properly, and it was not working properly during the research year, it is clearly vital that all HRVs be regularly checked. **Most homeowners service their own HRVs. (see http://www.cmhc-schl.gc.ca/odpub/pdf/62043.pdf) However, if homeowners feel that these tasks are beyond their capabilities, then there will be annual HRV maintenance costs to be considered**.

Combined Systems

As shown in Figure 4 and 5, combining R-2000 (an energy efficiency system) with passive solar architecture (a renewable energy system) meant that 53% of space heat needs could be met independently. Where a SDWH is combined with a demand water heater, the combination provides fully 59% of the required for the hot water demands of an average Canadian family of four (including one teenager). The combination of a renewable energy source and an energy efficient system puts natural gas in the role of backup energy source for both space and water heating.

Electricity savings can be found by combining many features, such as appliance selection, with lifestyle choices.

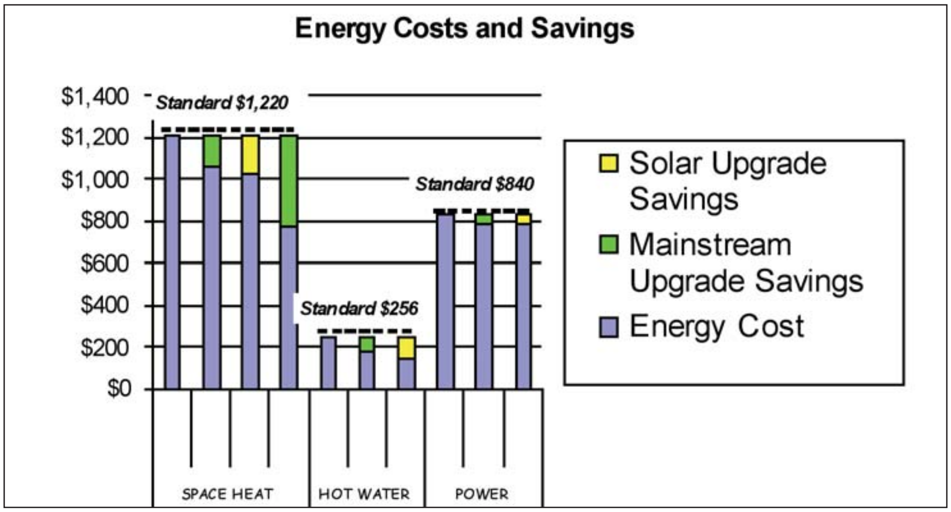

Figure 4 – Energy costs and savings in the Southfield Solar Model Home

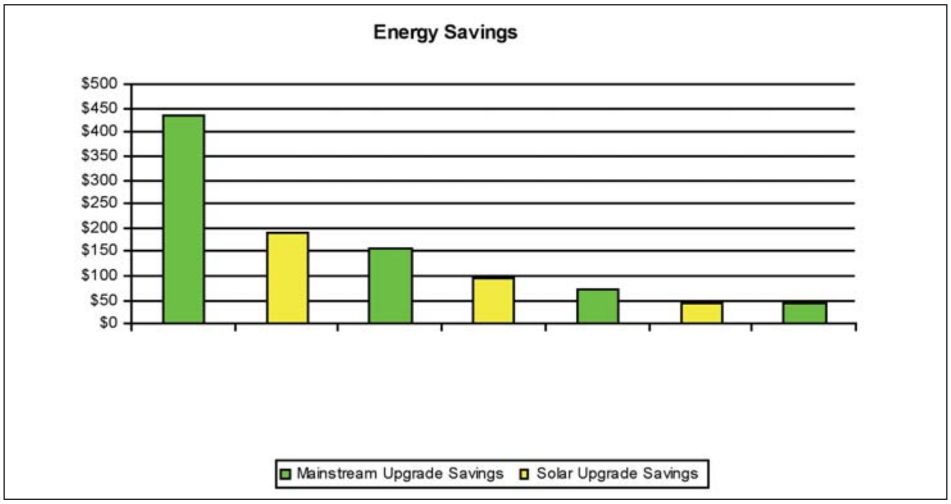

Figure 5 – Energy savings in order of contribution

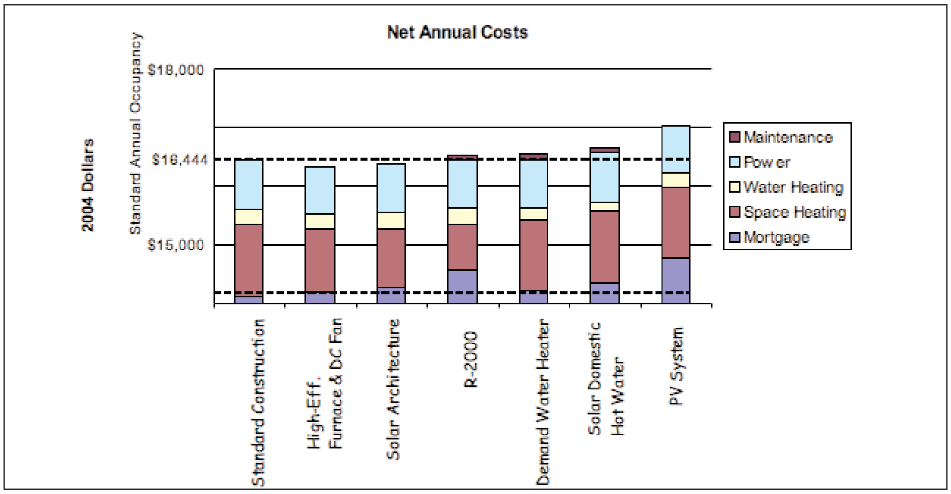

Figure 6 – Combined costs of energy, maintenance and financing for each energy upgrade, from lowest to highest.

Accuracy of Predictive Tools

The computer software that was used for estimating the houses' energy performance was Natural Resources Canada's HOT 2000 programme. (see http://www.sbc.nrcan.gc.ca/software_and_tools/hot3000_e.asp) The energy difference in predicted delivery of solar hot water compared to actual performance was 63% vs. 60%. HOT 2000 also predicted that the passive solar heating contribution to space heating would be 24% while the actual was 28%. Both these estimates are reasonably close, demo that Hot2000 is useful for design and estimating purposes. For details on the accuracy of demonstrating tools, click here. [hyperlink 5 Accuracy of Predictive Tools]

Energy-conscious landscaping is not only beautiful, but can add significantly to comfort, free time, and home value. Wise plant selection and placement can greatly reduce water, fertilizer and the need to maintain the yard – and cut down on the need to run energy-hungry lawn mowers and air-conditioners.

Tips to achieve ideal shade trees and alternatives to lawn are offered below.

Shade Tree Guidelines

- Locate tall, deciduous trees like maple, ash, and elm (not evergreens) on the south side of buildings close enough so that summer shade is cast over the roof and windows
- Prune lower branches forcing the tree to a high crown, thereby enabling low winter sunshine penetration into the building while achieving overhead summer shade
- Avoid trees with dense winter branching patterns to maximize winter sun penetration
- Choose locally adapted and native varieties for hardiness, longevity and drought and disease resistance, so that your tree remains healthy as it grows big enough to offer meaningful cooling.

Energy-Saving Landscaping Tips

- Xersicaping or dryland gardening, reduces the need for water.
- Rainbarrels collect water from the roof, conserving tap water.
- A late leafing tree allows in spring warmth, then leafs out when hot weather calls for cool shade.
- Varieties of fruit trees like cherry, plum and pear which do not require spray or pruning, contribute to household self-sufficiency.
- A vegetable garden can reduce travel to the grocery and replace energy-costly, imported food by fresh, seasonal abundance.
- Perennials like strawberry, raspberry and rhubarb can be ornamental and drought-tolerant. while reducing grocery trips.
- Wildlife-friendly vegetation provides stable and emergency food and shelter for animals, birds and pollinating insects
- Hardy perennial herbs (thyme, sage, oregano) add utility and diversity to landscapes; they're tolerant to drought, make fragrant paths, and stay green longer in the fall and winter.
- Vines are a fast-growing means of getting summertime shade and by evaporation cool the air; use trellised deciduous vines around hot sunny porches and windows.
- Reducing lawn area can cut down on mowing, fertilizing and watering, to reduce fuel consumption and offer free time for more productive, relaxing or rewarding pursuits
- Fragrant thyme or everbearing strawberries can be lawn alternatives that don't need cutting and resist drought better than grass.

Other landscaping tips can be found in CMHC's *Landscape Guide for Canadian Homes* (see http://www.cmhc.ca/en/inpr/su/sucopl/index.cfm)

***Hyperlink 4** – Energy-Wise Landscaping Measures at the Southfield*

Prior to construction, energy performance estimates were made for each system in order to assist in design and decision-making processes. With both predicted and actual sets of data, it was possible to ascertain accuracy and reliability of these tools, which has practical implications for how useful they could be for builders and avid home buyers.

HOT2000 and RETScreen software, both developed by Natural Resources Canada, were utilized. HOT2000 was used to estimate space heating effects of the R-2000 and passive solar design upgrades. It cannot model the SDWH contribution to the hydronically heated (radiant) basement floor, and can only partially estimate energy savings contributed by passive solar measures to cooling and lighting loads. RETScreen (www.RETScreen.gc.ca) was used to estimate solar water heating and photovoltaic energy contributions.

Software did accurately predict energy avoided or generated by individual systems. Although predictive tools and manufacturers' claims were well within measured ranges, the sum of the individual gas savings is not accurately reflected in natural gas bills. This could be due, in part, to visitors who occasionally turned off fans or otherwise created unequal conditions indoors, higher visitation of the baseline house next door which was the realtors' headquarters, or to sub-optimal performance of the heat recovery ventilator (see below).

HOT2000 predicted that the passive solar heating contribution to space heating would be 24%. Data analysis showed that actual contribution was closer to 28%, which could be considered natural variation. The winter was slightly sunnier than average, which could account for the slightly higher than predicted productivity.

Average Solar Radiation ($kWh/m^2/day$)			
	Normal Year	Monitored Year (01-02)	Difference
Jan	1.42	1.86	31/%
Feb	2.18	3.02	38%
Mar	3.21	3 39	6%
Apr	4.74	4.91	4%
May	5.2	4.34	-16%
Jun	5.81	5.43	-6%
Jul	5.96	4.96	-17%
Aug	5.24	4.72	-10%
Sep	3.81	4.91	29%
Oct	2.44	2.63	8%
Nov	1.24	1.31	6%
Dec	0.05	1.29	23%

RETScreen predicted that the Solar Domestic Water Heating (SDWH) system would produce 45% of hot water energy required for an average Canadian family of four in Guelph, Ontario. The measured hot water delivery was 39%. This is an acceptable degree of variation, but mostly can be attributed to the months of May, June, July and August 2003 all being cloudier than normal, months when maximum productivity can be expected.. This indicates also that the system reliably contributes useful heat even under poor sun conditions.

The demand water heater cut natural gas consumption for hot water heating by 29%, close to the manufacturer's claim of 20% savings.

Predicted output of the solar electric (PV) system according to RETScreen weather files for nearby Toronto was 7% of the load, or 629 kWh annually. Actual productivity was a reasonably close 6%, or 555 kWh. Again, this minor difference can be explained by weather conditions, dust, or random variation.

Overall, weather conditions explain most of the differences noted. Winter was sunnier than usual, hence winter space heating from solar was above expectations, while May, June, July and August, when solar water and electricity systems typically perform best, were all cloudier than average.

***Hyperlink 5** – How Accurate were Modeling Tools in Predicting Energy Savings?*

		UPGRADES						
Southfield Building to OBC standards		SPACE HEATING			WATER HEATING		ELECTRICITY	
	R2000	Passive Solar	High Efficiency	Furnace	Solar	Tankless	PV	ECM
System Cost ($)								
Purchase cost		8500	2648	1600	4500	1655	12 000	See H.E.F. Column
25% down		2125	662	400	1125	414	3 000	
Annual mortgage premium		594	185	112	308	116	837	
New maintenance		84	0	0	84	84	0	
Productivity								
Energy saved (kWh/yr)		12 202	5726	4433	2772	2072	675	519
Savings ($/yr)		436	193 (heat only)	202	99	74	57	44
Contribution to load (%)***	Space	36	16	13	N/A	N/A	N/A	N/A
	Water	N/A	N/A	N/A	39	29	N/A	N/A
	Electricity	N/A	undetermined	N/A	N/A	N/A	7	5
Net Cost Benefit Net Annual Cost Benefit ($)		-242	8+elec	90 (gas & electric)	-293	125	-780	
Annual occupancy cost (baseline $16, 444)		16686	16436	16353 (gas & electric)	16737	16569	17224	
# of years to payback at 2004 energy prices*		24.1	13.7 (heat only)	7.9 (gas & electric)	298.0	∞	210.4	
payback based on 10 yr projected rates of inflation**		14.7	9.0 (heat only)	5.5 (gas & electric)	67.6	58.0	177.7	
ROI based 2004 utility rates*		4.1	7.3	12.6 (gas & electric)	0.3	-0.6	0.5	See H.E.F. Column
ROI based on 10 yr projected rates of inflation		10.2	15.8	25.3 (gas and electric)	2.9	4.6	0.7	
Estimated lifespan (years)		about 20 (HRV)	∞	about 20	At least 20	15-20	∞	
Net Savings after 10 years ($)		- 156	1087	1810	-2415	-870	7699	
Greenhouse Gas Aversion GHG avoided (Kg C02 equiv./yr)		2255	998 (heat only)	857 (gas & electric)	512	383	50	See H.E.F. Column
Value (Kg C02 equiv. avoided/dollar invested)		0.27	0.38 (heat only)	0.54	0.11 water	0.23	0.004	
Warranty (years)		5 (HRV) Lifetime (core)	∞	Lifetime (heat exchanger) 5 (parts)	10 (panels) 5 (heat exchanger) 1.5 (pump	10 (heat exchanger) 5 (parts)	25 (panels) 5 (inverter)	5

Warranties on Solar Energy Upgrades in the Southfield House

1. Solar Architecture: Passive solar depends on orientation and layout design and uses high quality measures such as better windows and added thermal mass, so there are no other warranty issues than construction quality. So long as solar access is guaranteed, this system will endure for the lifetime of the building. A functional passive solar design balances heating and cooling demands in the home and minimizes daylighting loads and thermal extremes by attention to window area, room volume, thermal mass. (Use HOT2000, RETScreen or other appropriate modeling software.)
2. Solar Domestic Water Heating System: Two 4'x 8' solar collectors made by Solcan Ltd. in London, Ontario, are warrantied for 10 years for defects in workmanship and materials. The tank is warrantied for 10 years, pump 1.5 years, external heat exchanger and differential controller 5 years.
3. Grid-Tied Photovoltaic (PV) System: Consisting of 8 Siemens' 75 watt monocrystalline panels (25 year warranty) and an Advanced Energy Inc. inverter Model GC1000 (5 year warranty).
4. High Efficiency Furnace: Carrier Weathermaker Infinity 58MVP, 5 years except limited lifetime warranty on the heat exchanger.
5. Demand Water Heater: Rinnai Continuum 2402 carries a10 year warranty on the heat exchanger, and 5 years on parts.
6. R-2000: The R-2000 ventilation system requirement was supplied by a VanEE Gold Series Energy Recovery Ventilator, warrantied for 5 years, core for life.

Warranties on Solar Energy Upgrades in the Southfield House

Address
24 Jenson Boulevard
Guelph, Ont.

Building type
Four-bedroom single family, attached garage

Total heated floor area
208.2 m^2 (2,241 sq. ft.) plus basement)

Size of solar array
6 m^2 (64.5 sq. ft.) themal flat plate collections; 6.4m^2 photovoltaic panels

Solar description
Two 4 x 8 ft. solar thermal collectors, powered by a solar pump from a 20-watt PV module, a 360-L tank (80 gal.) with internal stainless steel heat exchanger; Eight grid-tied Siemens 100 Watt photovoltaic panels.

Solar water heating system cost
$5,550

Solar photovoltaic system cost
$12,000

Passive solar heating system cost
$2,648

Fuel source displaced
Natural gas

Estimated GHG emission reduction
2255 kg of CO_2 per year for the R2000 construction, 998 kg from the passive solar heating fraction only, 857 kg. for the hi-efficiency furnace, 512 kg from solar water heating, and 50 kg from PV

Savings
2,503 kWh/year

Percentage of south glazing to floor area
7.2 percent

Project developer-manager
Teresa Jeannine Paul
Nexus Solar Corporation
Saskatoon, SK
www.nexussolar.com

Builder
Dave Guardiero
Thomasfield Homes Ltd
Guelph, Ont.
www.thomasfield.com

Supplier
Nexus Solar Corporation
www.nexussolar.com

Scientific analysis
John Gusdorf
Buildings Group
Natural Resources Canada

Research adviser
Thomas Green
CMHC

R-2000 adviser
Gord Cooke
Air Solutions Inc.

Mechanical
Todd Harrison
Halls Heat and Cool Ltd.

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