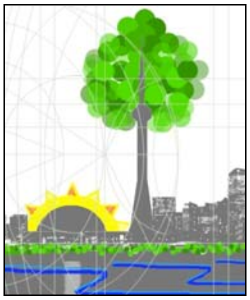

F I N A L   R E P O R T

TORONTO GREEN DEVELOPMENT STANDARD
COST-BENEFIT STUDY

Prepared for:

Policy and Research, City Planning
City of Toronto

TORONTO

By:

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Where Next Happens

FCM
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Executive Summary

This cost-benefit study represents part of a larger process to develop, implement and evolve the Toronto Green Development Standard (TGDS). The study report is aimed at practicing professionals and persons knowledgeable in the fields of urban development and green building technologies, but also attempts to convey its findings in terms that are accessible to citizen engagement.

The Toronto Green Development Standard is among a number of instruments being fashioned by the City of Toronto to address negative impacts associated with urban growth, but it is not intended to address all issues related to sustainable development. It has instead been based on a bio-regional approach to green development that recognizes the unique ecosystem that Toronto shares with the numerous communities that border the Great Lakes. In response to these bio-regional factors, the TGDS is premised on the following key environmental drivers:

- Better air quality;
- Reduced greenhouse gas emissions and urban heat island effects;
- Greater energy efficiency;
- Improved water quality and water efficiency;
- Less solid waste;
- Protection of the urban forest and wildlife habitat; and
- Reduced light pollution.

The City of Toronto received a grant from the Federation of Canadian Municipalities' Green Municipal Fund to undertake a feasibility study of green development, including a cost-benefit analysis of the Green Development Standard. Later, the City along with the University of Toronto was able to obtain funding from the Ontario Centres of Excellence. This study commenced in the summer of 2007 and targeted a report to City Council in early 2008.

Within its defined scope, the study has attempted to address the following objectives:

- Exploration of the issues and trends in green development across the Greater Toronto Area;
- Review of past and ongoing cost-benefit studies of green development to gain insights and compare findings;
- Completion of a cost-benefit analysis for the Toronto Green Development Standard according to various economic perspectives corresponding to builders/developers, consumers and society;
- Identification of the key opportunities for the development (or improvement) of products and services that enable cost effective green development while improving the competitiveness of Ontario's building industry;
- Dissemination of up to date and broadly accepted cost-benefit analyses of the economic and environmental impacts associated with implementation of the Toronto Green Development Standard;
- Identification of the technical and regulatory barriers related to various green building technologies;
- Communication of stakeholder perspectives and provision of invaluable feedback towards
- a structured process on how to evolve the Toronto Green Development Standard to render it more adaptable, effective and responsive; and
- Development of a multi-attribute cost-benefit analysis methodology that is extensible and adaptable to numerous stakeholders.

This cost-benefit study of the TGDS has concluded that the benefits derived from green development overwhelmingly outweigh the costs associated with building better. The marginal premium invested in measures to address the bio-regional drivers aimed at more sustainable forms of urban development can significantly improve the environmental, social and economic future, not only for Toronto, but the entire Greater Golden Horseshoe Region. The findings echo what has been reported in similar studies conducted across North America and around the world. They all confirm and reinforce the view that green development is not doing without, but doing better with less.

A unique perspective that emerges from this study is that once again, the City of Toronto has taken a leadership role on issues that affect the quality of life for present and future generations of its citizens. This report's findings are largely extensible to much of Ontario, thus leading to naturally speculate if the requirements of the TGDS deserve recognition in the Ontario Building Code and related regulations, standards and policies. The health and safety of the environment, not to mention society and the economy, deserves a voice in the regulation of minimum health and safety requirements for the built environment. Ecology, economy and social equity are all better served by cost effective requirements for buildings and developments promoting a sustainable future.

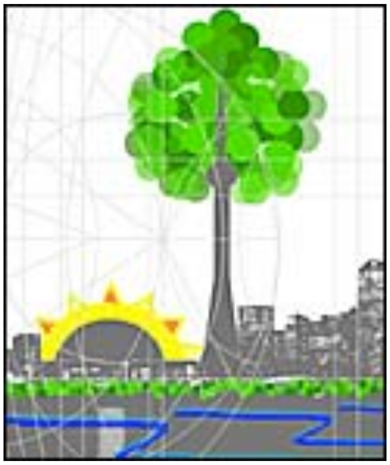
The *Conclusions and Recommendations* section of this report presents a complete set of conclusions and recommendations for the key stakeholders. The following synopsis highlights the key findings, issues and opportunities related to the implementation and ongoing evolution of the Toronto Green Development Standard.

- Contemporary societal values and attitudes support the concept of sustainable development founded on the principle of inter-generational equity. Development that is not sustainable is neither cost effective nor equitable.
- The present burdens associated with implementing the requirements of the TGDS are not excessive and may reasonably be expected to diminish as technological innovation and the diffusion of green development technologies become more widely implemented.
- Life cycle assessment of costs and benefits associated with building better is the only ethical and equitable means of assessing appropriate policies and practices. Despite its limitations, this economic measure can best estimate the full impact of decisions made in the present that affect the environment, society and the economy over the useful service life of buildings and their supporting infrastructure.
- Significant improvements to the quality and performance of building development are cost effectively achievable with currently available technologies. However, there is potential for even greater improvements through strategic investments in research and development (R&D) by the building industry. Like other major sectors of the economy, the building industry must seek to set aside, consolidate and appropriately allocate R&D resources.
- Societal inertia to green development remains a critical concern. A lack of suitably educated and trained personnel tend to discourage green development projects that do not conform to current approaches and practices. Going green continues to experience delays in getting the green light. Education, training, policies, regulations and procedures must be harmonized to privilege green development, rendering it a priority that is accessible and attainable.
- Recognition of green development as a societal priority must be extended to the retrofit and renewal of existing buildings because these represent a larger burden than new development. It is technically and economically feasible to improve the durability and performance of existing buildings, while exerting fewer adverse impacts than demolition followed by new construction.
- Renewable energy, water conservation and stormwater management are essential ingredients of green development. Appropriate policies and regulations are needed to attain all the potential synergies. Buildings and infrastructure must be considered together by all decision makers.

- Green development, in particular the renewable energy and energy efficiency (RE&EE) industry represents an opportunity to realize sustainable economic growth and the creation of jobs that cannot be outsourced. The RE&EE industry has the potential to offset job losses in Ontario's ailing auto industry and develop exportable knowledge and technologies.
- The performance labeling of buildings and developments is beginning to be implemented among progressive jurisdictions in North America and Europe. Third party certification provides consumers, financial institutions, utilities and policymakers with an accurate and reliable means of assessing energy efficiency, water conservation and environmental impacts. A consensus-based standard for performance labeling conforming to the protocol approved by the Standards Council of Canada, remains a logical mean of standardizing performance data that can be effectively conveyed to all stakeholders.
- Public education must complement performance labeling to achieve a mature market for green development. Unlike automobiles or consumer electronics, the performance assessment of buildings and developments involves numerous, complex measures that must be considered collectively. Many aspects of performance, such as water conservation and waste management, require social cooperation and there is a need to reinforce appropriate behaviour within the community context.
- Incentives that reflect the proper valuation of green development are needed to mobilize market transformation. Conventional (unsustainable) development must be discouraged by establishing development charge structures that reflect its accrued life cycle deficits. Conversely, green development must be encouraged by a coherent system of development charges and tax credits that economically reinforce socially and environmentally responsible behaviour.
- Municipal, provincial and federal policies and regulations must be harmonized to uniformly and consistently promote green development. Sustainable development must take precedence over many current regulatory practices that are often anachronistic remnants of unsustainable development patterns. Removal of disincentives is the key incentive, and governments must work with their stakeholders to identify and remove barriers to sustainable development.
- There is a need to conduct a series of demonstration projects in order to empirically confirm many of the findings in this study. The architecture, engineering and construction (AEC) industry are highly risk averse and resistant to change. While industry leaders have succeeded in implementing green development, this expertise has not diffused to the average industry player. Government projects and social housing are ideal candidates for carefully documented and monitored demonstration projects that inform the green development process, and reassure the AEC industry.
- Society cannot afford to lapse into a state of amnesia after it has addressed the challenge of sustainable development. Implicit within the concept of sustainability is the need to preserve, advance and transfer knowledge effectively. Monitoring the state of the environment, society and the economy and re-assessing our situation is a critical prerequisite for survival. The Toronto Green Development Standard is a product of this vital process, but it needs to be supported on a continuous basis, rather than intermittently. The pace of technological innovation and the forecast rate of growth require ongoing support of the TGDS so that it can anticipate future trends and respond effectively. In order to evolve, the TGDS must become a living document that is nurtured and educated by its stakeholders.

More than any technology or policy, green development hinges on our social imagination of a sustainable world, and the empowerment of people to behave responsibly without penalty. In the words of Albert Einstein, "*We cannot solve problems by using the same thinking we used when we created them*." This is the biggest challenge facing our common future, and the success or failure of the Toronto Green Development Standard will be a barometer of Toronto's trajectory.

Background



This cost-benefit study represents part of a larger process to develop, implement and evolve the Toronto Green Development Standard (TGDS). The study report is aimed at practicing professionals and persons knowledgeable in the fields of urban development and green building technologies, but also attempts to convey its findings in terms that are accessible to citizen engagement.

In November 2004, the Roundtable on a Beautiful City requested that (what was then) Urban Development Services report on the development and adoption of sustainable design principles and standards for Toronto. The City, in partnership with EETech, and Ontario Centre for Excellence, received a grant from the Federation of Canadian Municipalities (FCM) Green Municipal Funds to help in the preparation of this work. A working group of City staff and representatives of the Roundtable on the Environment and the Roundtable for a Beautiful City was formed to assist in guiding this work.

In Phase 1, the City engaged a consultant team led by Halsall Associates to conduct a study of other municipalities, internationally, which are leaders in the formulation and implementation of green development standards, so that Toronto could learn from their experiences. Thereafter, a consultation process was initiated to engage stakeholders on issues concerning the content and implementation of the green development standard. This consisted of an electronic survey of Toronto area developers, and a set of stakeholder workshops.

Phase 2 followed shortly thereafter with a study commissioned in early 2006. It produced a report in July 2006, *Making a Sustainable City Happen: The Toronto Green Development Standard*, which proposed the adoption of enhanced targets for site and building design that addressed matters of sustainability. It proposed an integrated set of targets, principles, and practices to guide the development of City-owned facilities and to encourage green development amongst the private sector. The *Toronto Green Development Standard* was created from a review of City guidelines and targets, private rating systems such as Leadership in Energy and Environmental Design (LEED) and Green Globes, and the experiences of cities from around the world. The *Toronto Green Development Standard* was proposed as a voluntary program, especially in the initial year of implementation, while further study and consultation was conducted.

> *Half the world's peoples will live in urban areas by the end of this decade. Whether we achieve a greater degree of environmental sustainability over that time will therefore be determined largely by our cities. Surely, sustainability is not possible in the long term unless we can soon find ways to regenerate our urban ecosystems, keep them in good health, and adapt more sustainable urban lifestyles.*
>
> Regeneration: Toronto's Waterfront and the Sustainable City: Final Report.
> David Crombie, 1992.

The conducting of a cost-benefit study emerged among the recommendations of the Phase 2 study. Undertaking a cost-benefit analysis of the various features of the green development standard was intended to address developers' concerns about the costs versus savings of implementation, and help the City to identify appropriate levels of incentives needed to achieve broader acceptance. The study would work to clarify the financial impact of the standard on the development community, and help to refine the level at which the standard is set, so that it is effective but also attainable for many developers. It would also help to ensure that the standard does not unfairly disadvantage firms unable to absorb or pass off the higher costs of construction, and that green development does not become a luxury item for purchasers. The study would provide a framework for ongoing monitoring of green development costs that could also provide vital feedback to refine the standard over time.

The City of Toronto has received a grant from the Federation of Canadian Municipalities' Green Municipal Fund to undertake a feasibility study of green development, including a cost-benefit analysis of the Green Development Standard. In addition, the City along with the University of Toronto was able to obtain funding from the Ontario Centres of Excellence. This study commenced in the summer of 2007 and targeted a report to City Council in early 2008.

Scope and Objectives

This cost-benefit study focuses on the relationship between the economic and environmental costs and benefits associated with green development. Green development is differentiated from sustainable development in this study simply because the ultimate ecological carrying capacity of the Greater Golden Horseshoe remains an unknown threshold. This absolute threshold can only be determined with complete certainty by collapsing the ecosystem, and thankfully such a determination remains beyond the scope of this study. However, there are sufficient early warning signs to indicate that we are near the tipping point, both locally in the GGH and globally, and that it is prudent to seek improved development practices . Hence, for the purposes of this study, its scope is limited to the prevalent forms of building development and the urban site technologies that support buildings, notwithstanding the multitude of social, economic and technological interactions that bear upon the sustainability equation.

Within this defined scope, the study has attempted to address the following objectives:

- Exploration of the issues and trends in green development across the Greater Toronto Area;
- Review of past and ongoing cost-benefit studies of green development to gain insights and compare findings;
- Completion of a cost-benefit analysis for the Toronto Green Development Standard according to various economic perspectives corresponding to builders/developers, consumers and society;
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- Development of a multi-attribute cost-benefit analysis methodology that is extensible and adaptable to numerous stakeholders.

It is important to appreciate that modeling the environmental behaviour of the built environment is not a precise science. Much of the information needed to assess current conditions, and hence forecast future scenarios, is often incomplete or absent. Environmental and economic thresholds are dynamic and not well understood until after a system collapses – an outcome the idea of green development wishes to avoid. Technological innovation and transformative physical phenomena, such as climate change and resource depletion, influence social behaviour in ways that are difficult to predict. This study acknowledges these limitations, but argues that some form of measurement and prediction is better than none at all. The only certainty is that green development may be expected to evolve according to environmental consciousness, economic capacity, technological capability and political will. Optimistically, the day may come when adjectives like 'green' and 'sustainable' will not precede 'development' and it will no longer represent a marketing term. Sustainability will hopefully come to be seen as not just cost effective, but the only possible future course of action.

Context for Green Development in Toronto

Humanity has the ability to make development sustainable - to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activity.
Our Common Future, World Commission on Environment and Development. Oxford University Press, New York, 1987.

The term 'development' can be applied at various scales. Sustainable Development has been applied anywhere from national programs of renewal to the construction of buildings. While development at the neighbourhood scale is within the City's jurisdiction and interest, this report, as the first step, specifically addresses the components of site and building design that can be made more sustainable. This is accomplished by establishing a series of targets that various site and building features should attempt to attain. In this work, and possible future work to address development at the neighbourhood scale, the objective is not to build bigger or smaller, as the case may be, but rather to build better.
Making a Sustainable City Happen – The Toronto Green Development Standard. City of Toronto, July 27, 2006.

Green development is part of a larger movement toward sustainable development that seeks to maintain mankind's ecological footprint within the carrying capacity of the environment. Issues like resource depletion, reduction in biodiversity, environmental degradation and climate change are among the many impacts related to the development of human settlements that have exceeded sustainable limits of growth.

The Toronto Green Development Standard is among a number of instruments being fashioned by the City of Toronto to address negative impacts, and it is important to recognize the TGDS is not intended to address all mechanisms and issues related to sustainable development. It has instead been based on a bio-regional approach to green development that recognizes the unique ecosystem that Toronto shares with the numerous communities that border the Great Lakes.

In response to these bio-regional factors, the TGDS is premised on the following key environmental drivers:

- Better air quality;
- Reduced greenhouse gas emissions and urban heat island effects;
- Greater energy efficiency;
- Improved water quality and water efficiency;
- Less solid waste;
- Protection of the urban forest and wildlife habitat; and
- Reduced light pollution.

The need to appropriately address these environmental drivers will represent major challenges not just to Toronto, but also the Great Lakes region and much of the developed world. The challenge can be best appreciated by considering the projected population growth in the Greater Golden Horseshoe (GGH).

Places to Grow

The Government of Ontario prepared and approved the Place to Grow Act, 2005 which came into effect on June 16, 2006. It was based on extensive research and consultation, and a number of key publications emerged through this process. A key publication establishing the terms of reference for the government's land use and planning legislation was produced by Hemson Consulting[1]. Tables 1 to 3 have been extracted from the study and these may be considered in conjunction with the Ontario government's official plan for growth in the GGH as explained in its Places to Grow publication[2].

The vision may be interpreted as being both bold and optimistic, simultaneously frightening and depressing. If the loftiest ideals of the vision are effectively implemented, then the GGH will enjoy economically, socially and environmentally sustainable growth by 2031. However, if the business-as-usual (BAS) approach to development is allowed to continue, then the adverse economic, social and environmental impacts will likely reverberate within the Great Lakes region, possibly across Canada. There is a fear that poorly managed growth within the GGH will plunge Canada's economic engine into an unsustainable spiral of economic recession that will be unable to support social programs and maintain environmental stewardship.

[1] *The Growth Outlook for the Greater Golden Horseshoe*. Hemson Consulting, 2005.
[2] *Growth Plan for the Greater Golden Horseshoe*. Ontario Ministry of Infrastructure Renewal, 2006.

Population forecasts for the GGH indicate that using 2001 as a datum, an additional 3,710,000 people will be dependent on new housing, municipal infrastructure, social services and employment opportunities by 2031. If the recent 2006 census population count for the GTAH of 6.06 million people is a reliable indicator, then the population projections indicated in Table 1 will not vary significantly.

Greater Golden Horseshoe Population Reference Forecast (in 000s)			
	GTAH	Outer Ring	Total GGH
1991	4,840	1,670	6,510
2001	5,810	1,980	7,790
2011	6,860	2,230	9,090
2021	7,780	2,560	10,340
2031	8,620	2,880	11,500
Growth, 2001–2031	2,810	900	3,710

Table 1. Population projections for the Greater Toronto and Hamilton (GTAH) area and the Greater Golden Horseshoe. (Source: Hemson Consulting and Statistics Canada)

Table 2 forecasts that from 2001 to 2031, an additional 1,750,000 jobs will be created in the GGH and the impact of this job growth will be most noticeable on transportation, both public and private. Unless future developments provide opportunities for workers to live near their place of employment, or be connected to it by an efficient public transportation system, vehicular traffic in the GGH is likely to become more congested, and this will in turn impact greenhouse gas emissions and air quality.

Greater Golden Horseshoe Employment by Place of Work Reference Forecast (in 000s)			
	GTAH	Outer Ring	Total GGH
1991	2,500	720	3,220
2001	2,940	870	3,810
2011	3,630	1,010	4,640
2021	4,030	1,130	5,160
2031	4,320	1,240	5,560
Growth, 2001–31	1,380	370	1,750

Table 2. Employment projections for the Greater Toronto and Hamilton (GTAH) area and the Greater Golden Horseshoe. (Source: Hemson Consulting and Statistics Canada)

During the same period, 2001 to 2031, it is forecast that 1,710,000 new households will be formed in the GGH (see Table 3). This growth will translate into a large number of housing starts accompanied by construction of other facilities such as schools, hospitals, offices, commercial/retail space, fire and police stations, etc. New roads and infrastructure needed to support the building developments will also need to be constructed.

Greater Golden Horseshoe Households Reference Forecast (in 000s)			
	GTAH	Outer Ring	Total GGH
1991	1,660	610	2,270
2001	1,970	710	2,680
2011	2,430	850	3,280
2021	2,860	1,020	3,880
2031	3,230	1,160	4,390
Growth, 2001–31	1,260	430	1,710

Table 3. Household projections for the Greater Toronto and Hamilton (GTAH) area and the Greater Golden Horseshoe. (Source: Hemson Consulting and Statistics Canada)

It is this approximately 50% increase to the the extent of the built environment across the GGH, from now until 2031, that defines the context for the Toronto Green Development Standard. The influence of the Greater Toronto Area (GTA) on planning, design and construction practices is well understood across the development industry. The approaches to development adopted in the GTA rapidly diffuse throughout the GGH. The view advanced by David Crombie that the battle for sustainability will be fought in cities is most strongly reinforced by the diffusion of construction and development technology. If large cities can effectively implement green development standards that cost effectively promote economic, social and environmental benefits, then these will serve as a model for suburban and rural communities. By the shear proportion of Canada’s population now living in cities, it is obvious that the context for a meaningful green development standard is the urban metropolis.

Further to the subject of technology diffusion is the realization that the new development being targeted through the TGDS is the tip of the built environment iceberg, simply because the existing built environment outnumbers the expected new growth. Existing buildings and infrastructure are far less energy efficient than even the least efficient of today’s developments, exerting a larger environmental footprint on a unit area basis. The impetus for new development to drive towards a more sustainable built environment will likely have strong spin-off effects on the retrofit of existing buildings, owing largely to the training of an entire industry. The move towards green development will require designers, contractors, trades, building officials, suppliers and manufacturers to gain a working knowledge of green building technologies, renewable energy systems and low impact development practices. Without a green development standard to spearhead the invention and adoption of more sustainable development practices, it is likely the regeneration of our cities will falter, and possibly fail, for want of useful knowledge, suitable incentives and effective regulation.

Study Outline and Methodology

Given the preceding context, this cost-benefit study was organized according to the process depicted in Figure 1. A significant component of the research was assisted by City of Toronto staff, who provided information and insights throughout the study.

Figure 1. Research methodology and outline employed in Toronto Green Development Standard Cost-Benefit Study.

Green Development Trends and Related Cost-Benefit Studies

The term "green development" implies that all other development is less than green. This terminology remains somewhat controversial and it is being increasingly recognized that development ranges across a spectrum from unsustainable to sustainable, depending on its spatial and temporal context, such that something in between can take on a corresponding shade of green.

What is Green Economic Development?
Those programs or initiatives that encourage retention, growth and attraction of companies or organizations which offer products or services that directly or indirectly reduce the impact on the environment.

People, Planet and Profit: Catalyzing Economic Growth & Environmental Quality in the City of Toronto. City of Toronto Economic Development, Culture and Tourism, May 2007.

Far less controversial is the realization that green development is a necessary response to many of the pressures associated with exceeding our limits of growth because of less than sustainable development policies and practices. Canadians' awareness of these pressures and attitudes toward the issues are evident in a recent Ipsos-Reid survey.[3]

- *In 1994, only 4% of Canadians noted the environment is the key issue that should receive attention by Canada's leaders, but in 2007 it's 40%.*
- *78% of Canadians believe that global warming, and hence climate change, is a scientifically proven fact.*
- *48% of Canadians are very concerned about climate change, the same proportion that feel the quality of our environment is "only fair" – and 69% say it is getting worse.*
- *32% of Canadians are optimistic environmental issues will get under control over the next 20 years – two out of three Canadians are more pessimistic.*
- *Only 28% of Canadian would be willing to make significant lifestyle changes to stop climate change.*

Green development is certainly important, but not important enough to cause a significant proportion of the Canadian population to change their lifestyles. By implication, the preference is for technological innovation to tame our environmental problems. It's as if average Canadians still want to go by the drive-through to pick-up their morning coffee and doughnut, but driving a zero emissions car and consuming organic, free trade coffee and trans fat-free pastry produced using solar energy. However, public attitudes can and do change, as can be witnessed by the banning of smoking in public buildings. In fact, the average Canadian consumer has become much more interested in just how green are the goods and services being offered by companies, who have become proxies of a vicarious environmentalism that seeks absolution for ecological sins through green consumption.

"Every product, brand, company and service will soon be telling a story - and they all need to be good.[4]"

"The management (including reporting) of non-financial issues and activities is becoming a proxy for evaluating the overall performance and ability of a company.[5]"

The trend in green development appears to follow trends in other segments of the economy - consumers prefer consuming green products over modifying their behaviour.[6] This has important implications for green development standards because the green rating associated with the consumer choice must be accurate, reliable and meaningful – and developers who don't deliver will suffer.

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[3] *Public Opinion About the Environment*. Ipsos-Reid Survey, September 2007.
[4] Corporate Social Responsibility (CSR) Report. Kingfisher PLC, 2007.
[5] Peter Johnson, Pricewaterhouse Coopers LLP, presentation to UNEP Finance Initiative, North America Taskforce, September 27, 2007.
[6] *Experts Workshop on Information and Consumer Decision-Making For Sustainable Consumption*. OECD, Paris, January 2001. http://www.oecd.org/dataoecd/46/19/1895757.pdf

This attitude has been identified in studies that have examined the unrealized potential for greener consumption patterns. Findings from a recent survey are summarized below.

The Greening Consumer – Unmet Needs[7]

1. Better water utilization.
2. Bigger shift to energy-efficient lighting.
3. Making it easier/more economical to set up personal energy grids – solar and wind power.
4. Knowing which products are actually better for the environment.
5. Get kids more involved in creating solutions.
6. Make it simple – link new action to known action.
7. Deeper information about what the company actually does to deliver on its promises.
8. Effective ways to recycle – especially old technology.
9. Attaining a better work/life balance.
10. Help reduce consumption versus selling more stuff.

The fourth and seventh points reinforce the view that consumers want access to good information to make appropriate choices. Rather than wanting to become educated, they want to be informed, simply and clearly.

Green Development Trends

How have these consumer attitudes towards greener products and services emerged in the area of green development? The overwhelming interest has been for goods rather than services. Buildings and appliances that can demonstrate energy and water savings are more preferable to green design, or environmentally responsible housekeeping and landscaping services. Energy efficient lighting is one of the best examples of how a technology that reduces expenses and ecological footprint without changing consumer habits has been widely embraced. The technology switchover is not disruptive and almost anyone is capable of changing light bulbs. As importantly, the energy rating that appears on each bulb is something that is independently tested on behalf of the consumer.

The trend for green development has had a similar trajectory where emphasis is more on quantifiable and verifiable performance. While there is a large number of green building rating systems, only recently have ratings for entire developments become available, and these remain in a pilot stage. Rating systems, such as LEED or Green Globes for larger buildings, and Energy Star for residential buildings, dominate the green development industry. The primary emphases within these rating systems are energy, water and resource efficiency. All of these parameters can be reasonably well estimated by design consultants, and there are a number of related rating systems in place for equipment, fixtures and appliances. Building performance, not the form of development or its relationship to the landscape and transportation systems, remains central to the green development industry. Indeed, this is openly declared on the Canada Green Building Council latest LEED Canada web page where the next generation of LEED Canada is touted as, "a 'buildings-centric' approach to climate change."[8]

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7 TBWA Vancouver, 2007.
8 Canada Green Building Council, http://www.cagbc.org/leed/index_en.htm

Beyond House or Condo – Sustainable Urban Planning
Our largest cities are becoming victims of their own success and many citizens are being squeezed out - we need to look beyond the 'house-or-condo' mindset and develop creative alternatives for compact development, densification and a cleaner, greener quality of life.

Avi Friedman, Professor of Architecture & Director of the Affordable Homes Program, McGill University, Montreal, Canada.

As of December 2007, there were a total of 654 registered LEED building projects across Canada, 75 of which are located in Toronto. Among these 654 registered projects, 90 buildings have been certified under LEED criteria for all of Canada, with 9 certified projects located in Toronto.[9] If these statistics are compared to the number of buildings constructed annually, it is possible to conclude there is very little interest in green development. Statistics Canada reported the value of building permits in the Toronto census area, for the period January to November 2007, had reached $11.98 billion, a 19.9% increase over the same period one year earlier.[10] It was not possible to estimate the value of the 75 LEED-registered buildings that obtained permits during 2007, however, various industry experts estimate less than 10% of new commercial and institutional buildings in the Toronto area are LEED registered. It is likely that a similar proportion incorporate green features but are not LEED registered. By comparison, it has been estimated that as of 2007 in Greater Vancouver, the green building market including registered and non-registered buildings) represented over 7% of permit values, or close to $400 million in annual investment.[11] Nonetheless, recent trends indicate the growth rate in registered LEED and Green Globes buildings, especially Energy Star homes, has been exponential in the past two years and industry professionals interviewed during this study reported that interest is growing among owners, particularly those with multiple building holdings who can witness the difference in performance and the business bottom line. The appeal of rating systems is demonstrable differentiation in the marketplace. But this differentiation is now being challenged by the improved energy efficiency requirements of the Ontario Building Code. The following is excerpted from Ontario Ministry of Municipal Affairs and Housing communications.

Energy Efficiency in the 2006 Building Code[12]
The 2006 Building Code enhances Ontario's leadership in energy-efficiency requirements for buildings through the introduction of higher requirements than the 1997 Building Code and previous codes. The higher energy-efficiency requirements balance energy efficiency with the affordability of a home. For example, the extra cost to build a home in 2007 to the new higher energy-efficiency standards will be recovered in three years through reduced energy bills. This will result in substantial long-term savings for Ontario households as well as reduced greenhouse gas production. Over the next eight years alone, the Building Code's increased energy-efficiency requirements will save enough energy to power 380,000 homes and reduce greenhouse gas emissions equal to 250,000 fewer cars on Ontario's roads.

Houses:
A typical new house built in 2007 under the new Building Code will be over 21 per cent more energy efficient than one built under the current Building Code. This will be achieved through requirements for:

- *More energy efficient windows (67 per cent increase in energy efficiency)*
- *Higher insulation levels (ceilings are being increased by 29 per cent, walls by 12 per cent and foundation walls by 50 per cent)*
- *High-efficiency gas and propane-fired furnaces (efficiency rating of 90 per cent).*

Further Building Code changes related to energy efficiency will be phased in:

[9] *LEED® Certified Projects in Canada* (excluding residential projects of less than 600m2). Canada Green Building Council, complete listing last updated: December 20, 2007.
[10] The Daily. Thursday, January 8, 2008. Statistics Canada. http://www.statcan.ca/Daily/English/080110/d080110a.htm
[11] *Green Building Market Insights*. Light House Sustainable Building Centre, Vncouver, Canada. http://www.sustainablebuildingcentre.com/about_us/Market_Insights_Sponsorship
[12] Ontario Ministry of Municipal Affairs and Housing (as of February 1, 2008 on web site) http://www.mah.gov.on.ca/Page681.aspx

- *New houses built under permits applied for in 2009 will require near-full-height basement insulation.*
- *New houses built under permits applied for in 2012 will be required to meet standards substantially in accordance with the national guideline, EnerGuide 80.*

Estimated Increased Capital Costs, Energy Savings and Payback Periods for Houses

	*Estimated Energy Savings**	*Estimated Increased Capital Cost**	*Simple Payback Periods*
Dec 31, 2006	*21.5%*	*$1,600*	*3.0 years*
Dec 31, 2008	*28%*	*$2,700*	*4.4 years*
Dec 31, 2011	*35%*	*$5,900 - $6,600*	*6.9 - 7.9 years*
*Note: Figures are based on a typical 2000 square foot gas-heated house in the Greater Toronto Area. *Compared to 1997 Building Code.*			

Non-residential and Larger Residential Buildings:
Energy-efficiency requirements are being increased for non-residential buildings and larger residential buildings built under the new Building Code in 2007. New non-residential and larger residential buildings built under permits applied for in 2012 will be required to meet standards 25 per cent higher than the Model National Energy Code for Buildings.

Estimated Increased Capital Costs, Energy Savings and Payback Periods for Non-residential and Larger Residential Buildings

	*Estimated Energy Savings**	*Estimated Increased Capital Cost**	*Simple Payback Periods*
Dec 31, 2006	*16 - 18%*	*$0.98 - $1.11/ft2*	*3.3 - 4.7 years*
Dec 31, 2011	*25%*	*$1.40 - $3.46/ft2*	*5.0 - 7.7 years*
*Note: The range depends on the size, climatic location, quality and method of construction of the building. Estimated cost increases are based on typical high-rise residential and high-rise office buildings. *Compared to 1997 Building Code.*			

Green Technologies:
New provisions will promote the use of green technologies such as:

- *Solar photovoltaic systems*
- *Active solar hot water systems*
- *Rooftop storm water retention*
- *Storm and grey water use.*

These changes come into force immediately. The Ministry of Municipal Affairs and Housing held province-wide public consultations on the energy-efficiency changes from February to April 2006. A technical advisory committee comprising designers, builders, regulators, manufacturers, and energy suppliers and advocates reviewed the input from these consultations. The technical committee's recommendations were reviewed and are closely reflected in the Building Code changes. [**End of Excerpt**]

As codes and standards for buildings, equipment and appliances continue to improve energy and water efficiency, other regulations pertaining to stormwater management and similar environmental protection measures are further greening minimum requirements. Green buildings from just a few years ago may be less green than soon to be constructed Code-minimum buildings. The enhancement of minimum requirements and consumer expectations are demanding that buildings be completely re-designed rather than simply bolting on green technologies. Demonstrable differentiation is quickly becoming the green development industry's latest design problem. The most significant trend in green development is that "It's Not Easy Bein' Green" has taken on new and unexpected dimensions.

Related Cost Benefit Studies

A review of related cost-benefit studies was conducted as a parallel process along with an assessment of energy conservation measures and urban site technologies, presented in subsequent sections of this report. This approach was intended to compare what has been reported internationally with the actual costs and benefits associated with green development in Toronto. The discussion that follows is based on the key environmental drivers underlying the Toronto Green Development Standard. The various studies are presented chronologically, and it should be noted that less than a decade ago, there were practically no cost-benefit studies conducted in this area.

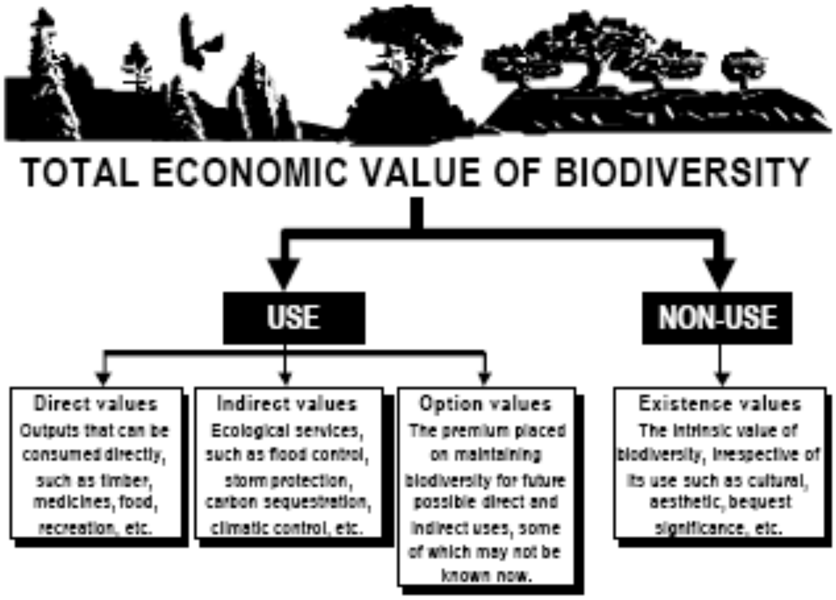
Health and Productivity Gains from Better Indoor Environments and Their Relationship with Building Energy Efficiency. William J. Fisk, Annual Review of Energy and he Environment, Vol. 25, pp. 537-536, 2000.
http://eetd.lbl.gov/ie/viaq/pubs/FiskAnnualReviewEE2000.pdf
Theoretical considerations and empirical data suggest that existing technologies and procedures can improve indoor environments in a manner that significantly increases productivity and health. The existing literature contains moderate to strong evidence that characteristics of buildings and indoor environments significantly influence rates of communicable respiratory illness, allergy and asthma symptoms, sick building symptoms, and worker performance. Whereas there is considerable uncertainty in the estimates of the magnitudes of productivity gains that may be obtained by providing better indoor environments, the projected gains are very large. For the United States, the estimated potential annual savings and productivity gains are $6 to $14 billion from reduced respiratory disease, $1 to $4 billion from reduced allergies and asthma, $10 to $30 billion from reduced sick building syndrome symptoms, and $20 to $160 billion from direct improvements in worker performance that are unrelated to health. Productivity gains that are quantified and demonstrated could serve as a strong stimulus for energy efficiency measures that simultaneously improve the indoor environment.

The Use Of Economic Measures In National Biodiversity Strategies And Action Plans: A Review of Experiences, Lessons Learned and Ways Forward. Lucy Emerton, The World Conservation Union, 2001.
http://www.undp.org/biodiversity/biodiversitycd/use%20of%20economic%20measures%20in%20NBSAPs.pdf
This report is a summary of a review of the use of the use of economic measures in National Biodiversity Strategies and Action Plans (NBSAPs) completed by The World Conservation Union (IUCN) in 2000/01. This study involved a review of existing literature on a global basis, the supervision of five case studies, a workshop and a final report.

Economic justification of NBSAPs is critical to their success, in terms of their ability to overcome the economic causes of biodiversity loss and their ability to ensure that economic incentives are set in place to encourage the conservation of biodiversity as outlined in the Convention on Biodiversity (CBD) which holds valuation, incentive measures and financial resources as being three key contributors to biodiversity conservation.

Economic valuation of biodiversity is a complex matter as traditional valuation processes only consider biological resources in terms of the direct uses they support, which under-values biodiversity by limiting the focus to the “commercial-level extraction of resources, often at the expense of other, less tangible, values.” This under-valuation often makes the justification of conservation more difficult when compared to less sustainable resource use with apparent greater and more immediate economic returns.

Figure 3: The total economic value of biodiversity



Commonly used tools for valuing biodiversity include market prices, effects on production, replacement costs, damage costs avoided, mitigative or avertive expenditures, travel costs, and contingent valuation.

Commonly used instruments as an attempt to overcome direct and underlying causes of biodiversity loss include property rights, markets and charges, fiscal instruments, bonds and deposits.

Key elements in the design of economic measures for NBSAP implementation include:

- ensure that expected benefits are greater/equal to costs (implementation, administration and enforcement)
- utilize a mix of mutually supporting incentives and disincentives
- ensure adequate monitoring and evaluation of their impacts; and
- need to be accompanied by a range of other technical, legal, social and institutional actions and measures.

A Blueprint for Green Building Economics. David Gottfried. Environmental Design and Construction, July 2003.
Through an assessment of the costs and income & expenses associated with green building vs. traditional construction, the author provides an analysis that can be used as rationale for green building in the private sector.

Project Costs
The author analyses the three types of costs contributing to a building project's total cost - site acquisition, direct and indirect costs, and concludes the following:

- Site acquisition for green building does not result in higher costs, but will simply require a more careful inspection of potentially "green" site characteristics.
- Direct construction costs are not necessarily higher for green construction. Incremental add may be 4%, but with experience (City of Seattle) this can be reduced to below 1%.
- Indirect construction costs may include items such as certification and tenant lease-up contingency, but these may result in higher perceived value. In addition, traditional indirect construction costs such as professional design services are not as frequently subject to premiums for providing "green" building services, and in general these premiums are declining.

Income & Expenses
The author analyses the three types of costs contributing to a building project's income and expenses including rental rates, vacancy rates, expenses, financing & equity, and return on equity/project valuation:

- Income benefits associated with green buildings can bee seen in lower vacancy rates due to tenant comfort, health and productivity.
- It is less clear from the present-day data set (as green building is so new) that increased rental rates are always possible. However, communication of enhanced value to prospective tenants is critical.
- The operating expenses of green buildings have been shown to be significantly lower – due to potential energy reductions of 30 to 50% and 30% lower water consumption, decreased waste generation and fewer repairs and maintenance.
- Green buildings can result in lower insurance premiums and owner liability.
- Green buildings can achieve higher valuations, resulting in higher loan amounts and higher building valuation.
- Increase income, lower expenses and reductions in financing results in a more profitable building.

The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force. Gregory H. Kats et. al., October 2003.
http://www.cap-e.com/ewebeditpro/items/O59F3259.pdf
This report is the summary of an economic analysis project led by California's Sustainable Building Task Force. The goal of this economic analysis was an "effort to evaluate the cost and benefits of sustainable building".

In addition to an extensive literature review, the project looked at the costs of 33 green buildings (in California and elsewhere), and compared them to the costs that the same building would have incurred as a typical (non-green) construction. A summary of the most relevant conclusions is presented in Table 1. In addition, it was also concluded that the earlier that green concepts are incorporated, the cheaper the cost of building green.

Table 1 - Summary of Results	
Average premium of a green building	2%*[13]
Average savings over life of building	20%*[14]
Energy reductions	25-30%
Peak demand reduction below average	10%
*the majority of which is due to up-front design time ** with an up front investment of 2%, using a 5% discount rate and a 20 year period (as a conservative average between envelope and energy equipment expected life).	

This report discusses the value of pollution reduction associated with an energy reduction, but does not take into account peak reductions, though notes that this is important. The report contains in-depth discussions of the economic impacts of several other items related to green buildings, including:

- reduction in water use (indoor use – over 30%, outdoor use – over 50%;
- a 50-75% diversion of construction & demolition waste; and
- the productivity and health of employees.

The report reference numerous studies completed in California and elsewhere, and a summary of the overall financial benefits of green buildings can be found in Figure ES-1, from the report's Executive Summary.

Figure ES-1. Financial Benefits of Green Buildings
Summary of Findings (per ft^2)

Category	**20-year NPV**
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only) - 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Certified and Silver)	$36.89
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Gold and Platinum)	**$67.31**

Source: Capital E Analysis

[13] The majority of which is due to up-front design time.
[14] With an up front investment of 2%, using a 5% discount rate and a 20 year period (conservatively, as an average between envelope and energy equipment expected life).

Integrated Design Charrette Report: Minto Midtown & Metro Label Printing. Sustainable Buildings Canada, June 3, 2003.
This report summarizes a design charrette held at Toronto City Hall on June 3, 2003, hosted by Sustainable Buildings Canada. The purpose of the one day charrette was to provide alternative design scenarios for two projects: Minto's Midtown condominium and Metro Label's printing facility in Scarborough, using an "integrated design process", which is based on the idea that an integrated team, made up of members with diverse experience and formed early in the process can produce "superior environmental design alternatives".

The event was attended by more than 100 participants and five teams were created: three teams to investigate scenarios for Minto's Midtown (Teams 1-3) and two teams to investigate Metro Label's printing facility (Teams 4-5).

Team 1 – MInto CBIP energy efficiency scenario
Team goals were to meet CBIP, achieve a high level of comfort for the occupants and implement water efficiency measures. Team 1 demonstrated that approximately 30% better than MNECB is achievable using market available equipment, including improvements in lighting at a capital cost of $25,000 that yield $21,000 in annual savings.

Team 2 – MInto C-2000 scenario
Team goals were to meet the C-2000 guidelines, which are expected to consume 45% less energy than MNECB (baseline building at 6.2% below MNECB), and to adhere to strict indoor environment guidelines and limitations on solid waste, emissions and consumption. At the conclusion of the charrette, the team was able to reach a 35% reduction below MNECB and concluded that with additional manipulation of envelope values, fan efficiencies and energy efficient appliances, the design would be able to meet this goal.

Team 3 – Minto open-ended high performance scenario
Team goals were to optimize environmental performance of the building including energy efficiency, water and wastewater minimization, consideration of renewables, etc. The Green Globes model results of this team's design achieved a rating of 4 out of 5 Green Globes.

Team 4 - Metro Label Building System and Energy Efficiency & Team 5 - Site, Materials
The teams attempted to achieve as many relevant LEED credits as were technically and economically feasible, and succeeded in developing a design that would allow the Metro Label printing facility to achieve a LEED Gold Rating.

This report presents the successful application of the integrated design approach to achieve various shades of green buildings cost effectively.

Investing In "Green" Building Alternatives: U.S. Consumer Willingness-To-Pay. Kevin R. Grosskopf. The Future of Sustainable Construction (2003).
http://www.cce.ufl.edu/Investing%20In%20Green%20Building%20Alternatives.pdf
This report summarizes research into consumer willingness to pay for green building alternatives, and the extent to which initial costs and lifecycle return on investment ROI impacts this willingness. The study looked at several high-efficiency alternatives simulated in different climactic regions of Florida, and surveyed more than 400 new home buyers in these regions.

The study demonstrated the following:

- 90% of respondents were willing to invest in green alternatives for either hard or soft cost benefits.
- Willingness to pay for soft cost benefits ranges from 33.8% to 61.1%
- As savings to investment ratio decreases, consumers are less willing to pay.
- On average consumers were most willing to pay for high cost, high return alternatives (42%), and less willing to pay for lower cost, lower return alternatives (22-25%), particularly among consumers 35 years of age and older.
- Willingness to pay increases for high cost high return alternatives as consumers approach the 35-45 age bracket (up to 52%), and then decreases to 37% by the age 65.
- Low cost, low return alternatives remain between 20% and 30% acceptability for all age groups.

The study concluded that professionals with annual incomes greater than $65,000/year in the 45-54 age bracket are nearly twice as likely to invest in high-performance green buildings than lower income respondents ($34,000 or less/year) who are less than 35 years old.

Managing the Cost of Green Buildings: K-12 Public Schools, Research Laboratories, Public Libraries, Multi-Family Affordable Housing. Geof Syphers, et al., October 2003.
http://www.ciwmb.ca.gov/greenbuilding/design/ManagingCost.pdf
In response to the lack of published information on how to economically build non-office building types, this report provides strategies for cost-savings associated with four different building types: K-12 schools, laboratories, libraries and multi-family affordable housing.

Estimates of the cost of green have been revised downward in recent years, to reflect a 0%-3.5% increase in capital cost for LEED Silver, 0.5%-5% for LEED Gold and 4.5% - 8.5% for LEED Platinum. To further minimize the costs of green building, the following strategies should be implemented:

- Determine whether LEED (other) certification is a necessity.
- Recognize that LEED projects cost less than expected.
- Set green goals early and be clear in your commitment and expectations.
- Use an integrated, holistic design process.
- Invest an additional 3% in design to yield 10% savings in cost of construction (design simplifications and reduced change orders).
- Build a good design team, educate them and identify good sources of information.
- Involve the contractor and mechanical electrical and plumbing early in the design process.
- Understand commissioning and energy modeling.

- Seek out rebates and incentives; leverage external funding sources.
- Keep in mind the objectives of the decision makers.
- Develop reasonable base case budget assumptions to reasonably estimate the cost of green.
- Do not consider "green" as separate from standard construction process.
- Streamline decision-making process.
- Optimize use of daylighting.
- Engage owner/tenant.
- Leverage economies of scale.

Market-Based Incentives for Green Building Alternatives. K.R. Grosskopf and C.J. Kibert, The Future of Sustainable Construction, 2003.
http://www.cce.ufl.edu/Market-Based%20Incentives%20for%20Green%20Building%20Alternatives.pdf
This report is a summary of research into market-based incentives and demand-side water management as an alternative to water treatment capacity increase in the Tampa Bay region.

Residential development accounts for more than a third of all contracted construction and 86% of this is single family housing. A single family dwelling can use as much as 40% of available potable water for non-potable use.

The report defines the most appropriate Best Management Practices to effectively reduce this water consumption as:

- Non-potable irrigation
- Water efficient landscape
- Low-flow clothes washer
- Low-flow toilets

Tampa Bay Water has enacted a comprehensive five-year demand-side management program to invest in "water reuse infrastructure, monetary incentives (rebates), conservation services, and public education in an effort to defer capital expansion and operations costs", as summarized in Table 1.

Table 1. Average rebate incentives and program cost for water BMPs for six participating utilities in the Tampa Bay Water association.[5]

BMP	Incentive ($U.S.)	P_{2004}: Total 5-year program cost ($U.S.)	$S_{20\text{-}yr}$: Total 20-year water savings (ML)	E/C: Program cost per 1,000L ($U.S.)
Non-potable irrigation	350 (¥2,870)	46,467	730	0.06 (¥0.50)
Landscape evaluations [a]	200 (¥1,640)	219,934	5,848	0.04 (¥0.33)
Landscape evaluations [b]	960 (¥7,872)	258,586	1,914	0.14 (¥1.15)
Low-flow toilets	150 (¥1,230)	7,993,464	31,109	0.26 (¥2.13)
Reclaimed irrigation	0 (¥0)	149,885,581	285,268	0.53 (¥4.35)
Low-flow clothes washer	0 (¥0)	0	0	0.00 (¥0.00)
Totals		158,404,032	324,869	0.49 (¥4.02)

[a] – without rebates
[b] – with rebates

The report goes on to describe the Demand-Side perspective of this program and the economic efficiencies of the individual BMPs from this perspective.

Consumer Willingness to Pay
Research conducted by the University of Florida found that homeowner willingness to pay was "strongly correlated to capital cost recovery (CCR) and to a lesser extent, savings-to-investment ratio (SIR)" and was also related inversely to the time to recover capital costs.

There is a discussion of the externalities of water use, including energy consumption and emissions generated.

A Business Case for Green Buildings in Canada. Mark Lucuik, Morrison Hershfield, 2005.
http://www.cagbc.org/uploads/A%20Business%20Case%20for%20Green%20Bldgs%20in%20Canada.pdf
One of the most important sections of this report deals with productivity and salary cost gains. This section indicates that a 1% increase in productivity equates to a $2/sf/year savings, but that in a world where owner-occupied buildings are not the norm, it is more difficult to accurately reflect these savings in the business case.

Water Use - On the assumption of a green building water use reduction of 30%, associated indirect costs savings can amount to 0.30 to 0.58 $/ft^2 per year.[15]

The report summarized the findings of several studies related to productivity gains in green buildings, indicating that it is difficult to synthesize these summaries into one larger set of observations.

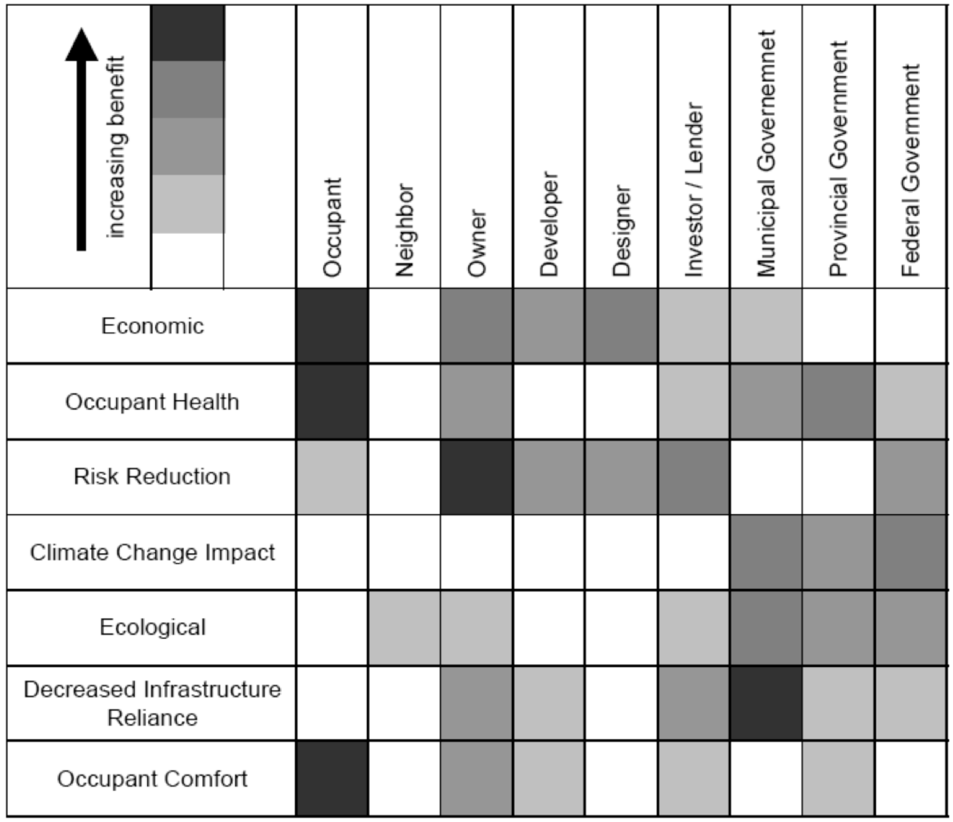
Nevertheless, there certainly is a strong indication that occupant productivity is greater, and that salary costs are reduced, in green buildings compared to conventional buildings. The magnitude of this difference is not clear, but it would be reasonable to assume a productivity gain of between 2 and 10% when moving from an average building to a green building that incorporates high quality natural light, exceptional ventilation, and possibly user controls. For most office buildings, even the 2% gain will be sufficient to more than compensate for any extra costs associated with the design and construction of a green building.[16]

In the report summary, several important benefits of green buildings were noted:

- Superior Occupant Comfort and Health
- Ecological benefits and Reduced Climate Change Impact
- Reduced Operating Costs
- Productivity Gains
- Property Value and Absorption Rate gains
- Increased Retail Sales
- Improved Image
- Risk Reduction

These are summarized in Figure 4 of the original study which presents a matrix of green building stakeholder benefits.

[15] p.31.
[16] p.26.



The report presents conclusions of “numerous recent North American multi-building studies on the qualitative effects of green buildings” which were found to reveal the following:

- Good daylighting increases productivity by 13%, can increase retail sales by 40%, and can increase school test scores by 5%
- Increased ventilation increases productivity by 4 to 17%
- Better quality ventilation reduces sickness by 9 to 50%
- Increase ventilation control increases productivity by 0.5 to 11%
- High glare reduces performance by 15 to 21%

Report on the Environmental Benefits and Costs of Green Roof Technology.
Doug Banting, et al. for City of Toronto, 2005.
http://www.toronto.ca/greenroofs/pdf/fullreport/103105.pdf
This report was prepared for the City of Toronto and Ontario Centres of Excellence – Earth And Environmental Technologies (OCE-Etech) by faculty and students at Ryerson University, in an effort to investigate the benefits on a municipal level of implementing green roof technology in the City. The study included a literature review, a survey of existing technologies and standards with respect to green roofs, research on the existing building stock in the City, and a methodology for calculating the financial value of the benefits of green roofs on a city-wide basis.

Research into the benefits of green roofs, identified key quantifiable benefits that would be used in the analysis: stormwater flow reduction (including impact on combined sewer overflow), improvement in air quality, energy use reduction, and reduction of the urban heat island effect. Other, less quantifiable benefits identified included increased biodiversity and the use of green roofs for food production or amenity space.

The calculation of the financial benefits of the implementation of a green roof program on a city-wide basis are excerpted from Table 5.1 on page 59 of the report and summarized below. The assumptions related to green roof coverage are based on the "greening" of 100% of the available flat roofs larger than 350 m^2.

Table 5.1
Summary of municipal level environmental benefits of green roof implementation in the City of Toronto (Assuming green roof coverage of approximately 5,000 hectares

Category of benefit	Initial cost saving	Annual cost saving
Stormwater		
Alternate best management practice cost avoidance	$79,000,000	
Pollutant control cost avoidance	$14,000,000	
Erosion control cost avoidance	$25,000,000	
Combined Sewer Overflow (CSO)		
Storage cost avoidance	$46,600,000	
Reduced beach closures		$750,000
Air Quality		
Impacts of reduction in CO, NO_2, O_3, PM_{10}, SO_2		$2,500,000
Building Energy		
Savings in annual energy use		$21,000,000
Cost avoidance due to peak demand reduction	$68,700,000	
Savings from CO_2 reduction		$563,000
Urban Heat Island		
Savings in annual energy use		$12,000,000
Cost avoidance due to peak demand reduction	$79,800,000	
Savings from CO_2 reduction		$322,000

A Study Into International Directions For The Mandatory Disclosure Of The Energy Performance Of Buildings. Faber Maunsell for the Australian Greenhouse Office, 2005.
This report outlines a 2005 study of mandatory energy performance disclosure programs, conducted by FaberMaunsell as consultant to the Australian Government. The study reviewed in particular the Europe Union Member States who had a mandate to incorporate an energy disclosure scheme as per the Energy Performance of Buildings Directive (EPBD) by January 2006.

Key Issues
Several key issues were noted in the report:

- Regulatory frameworks – mandatory vs. voluntary disclosure; international experiences with these types of programs.
- Financial and environmental costs and benefits of the implementation of such a program.
- Securing stakeholder commitment – issues of consistency, confidentiality.

Technical aspects of mandatory disclosure were also noted:

- Component compliance vs. whole building energy use. The traditional use of component compliance
- Predicted energy consumption vs. actual consumption. Actual consumption often varies widely from calculated predicted consumption, due to user behaviour and control. How is this reconciled?
- Existing buildings vs. new buildings. With generally higher energy consumption, energy use in existing buildings is harder to control; little regulation is generally in place to deal with existing structures.
- Performance assessment tools - simple vs. complex models. Simple may be more suited to regulatory use; complex models may be more accurate, but require detailed input data and well-developed databases.
- Frequency of assessment and reporting.
- Availability of competent technicians.

Conclusions
There are many issues to consider when implementing a mandatory disclosure of energy performance of buildings program, and while there are likely significant benefits to these countries that have such programs in place, they have not yet been identified and/or quantified.

Building Performance: What the Users Say. (Published as "Within These Walls", Safety and Health Practitioner, Adrian Leaman, 2005.

Building Use Studies, a consultancy based in London, has been compiling building performance information over the past twenty years. Their approach is somewhat different from typical building performance analysis in that it deals only with the opinions of the building users. The issues considered important to users is complex due to the extensive list of aspects that to be assessed and the diversity of building types, uses and tenants, but the author distills these into three main questions to be answered:

- Does the building performance help or hinder productivity at work?
- Is the building good value for money as an investment?
- Does the building have low environmental impacts.

The author has found that non-domestic buildings which answer all three of these questions positively are very rare[17]

What the Users Say
Occupant satisfaction is highest when the following items are in place (their priority changes based on the situation):

- **Stable thermal conditions**. These should be predictable throughout winter and summer, with effective user intervention if thermal conditions become uncomfortable.
- **Rapid response when things go wrong.** If needs are met faster, the user is more satisfied even if resulting response is not perfect (eg. operable windows)
- **Convenience.** Occupant control that requires only occasional intervention and not constant monitoring. These controls must be simple and well communicated to occupants if they are to tolerate inevitable system faults.
- **Absence of unwanted interruptions**. Noise, etc.
- **Adjustable furniture.**
- **Natural light.** Almost always preferred to artificial, in the absence of glare and heat gain.
- **Cleanliness.**
- **A modest image.**
- **No conspicuous waste.** Occupants tent to notice energy inefficiencies.

[17] 1 in 100, as an optimistic estimate.

Green Building Can Make Financial Sense. Alan Scott and Bruce Wood. Land Development Today, May 2005.
While numerous reports have been written touting benefits of green buildings, the incremental capital costs described (-1% to +6%) are borne by the developer, while the benefits (energy cost savings – 20% to 60%; water cost savings – 10% to 30%; workforce productivity gains – 5% to 16%) accrue to a long-term owner/occupant. This report intends to characterize green buildings as a sound investment from the point of view of the commercial real estate developer.

The report describes three types of commercial developer and their "unique financial drivers".

- merchant developer. This type of developer's profit is only influenced by project costs, the first year's income and thus the market value of the property based on ROI.
- An owner/developer is a longer-term investor, and uses IRR analysis and a ten-year cash flow horizon.

In both cases, higher lease rates are critical to the acceptability of any additional investment required to develop a green building.

- The build to suit developer has more flexibility and often uses a capital budgeting model when deciding on investments. Using a cost of capital of 15%, investments in technologies can make sense if energy savings over a 10 year timeframe can give an acceptable IRR.

Other benefits that are not as easily predicted and quantified as they vary depending on jurisdiction and development model, can include such things as: reduced (or cost-neutral) development costs, rapid absorption into the market, increased Net Operating Income (NOI)/higher rents, higher appraised building value, reduced vacancy, improved public relations.

High Performance Building Design in Minnesota. The Weidt Group for the Minnesota Office of Environmental Assistance, 2005.
http://www.pca.state.mn.us/oea/publications/highperformance-weidt.pdf

This report summarizes a project involving the analysis of performance data for High Performance Building projects in Minnesota. Over 170 projects were screened to determine if they met the predetermined threshold of 30% annual energy dollar savings over code and 41 projects met the criteria. Building types reported in the study include: school, library, retail, office, mixed use, hospital, recreation centre, police/fire station and laboratory.

"The 41 High Performance buildings surveyed contain over 7 million square feet of floor area, with combined annual savings of over:

- 58,000,000 KWh
- 15,000 Peak KW
- 290,000 Natural Gas MMBtu
- 5,250,000 dollars
- 118,000,000 lbs CO_2 emissions
- 205,000 lbs SO_2 emissions
- 225,000 lbs NO_x emissions
- 15,000 lbs Particulate emissions
- 1.9 lbs Mercury emissions" (page 2)

Key energy savings strategies employed in these High Performance Building projects include improved insulation levels and improved glazing, but the strategies with the most significant savings include improved lighting design (average 33% energy dollar savings in retail), lighting controls (average 15% savings in schools), load responsive HVAC design (average 35% savings in office), and conditioning of outside air (average 41% savings in schools).

Green Buildings and the Bottom Line. *Building Design and Construction*. Reed Business Information, 2006.
http://www.bdcnetwork.com/contents/pdfs/whitepaper06.pdf
This report summarizes numerous studies on the benefits and costs of green buildings, and concludes with a "10-point Action Plan" for contemplation by stakeholders in the green building field. Also summarized are the results of a survey of architecture, engineering and construction firms who subscribe to *Building Design + Construction*.

The report summarizes numerous valuable studies; the following are a few of the noted findings and observations.

Health & Productivity
The benefits of green buildings related to occupant health and productivity far outweigh benefits in terms of reduced operating costs.

- Study of impact of daylighting on retail sales reveals an increase of 40%.
- Industrial buildings case study – Castscon Stone Inc. in Pennsylvania, new green facility – 25% improvement in manufacturing productivity and 30% decrease in energy use per square foot.

A review of hundreds of studies related to green buildings and health benefits conducted by researchers at Carnegie Mellon University revealed

- Reduction of respiratory illness by 10-90% in buildings with high-performance ventilation systems.
- Performance gains of 0.2%-7% related to temperature control
- 74% reduction in headaches through replacement of magnetic ballasts with noise-free electronic ballasts.
- Improved lighting design resulting in productivity increases between 0.7% and 23%.

Public Relations
In the near term, the marketing and public relations aspects of green buildings are effective tools. In the eventuality that green building becomes the standard, less attention will be paid to green buildings.

The Dollars and Sense of Green Buildings: Building the Business Case for Green Commercial Buildings in Australia. Green Building Council Australia, 2006. http://www.aela.org.au/publications/Dollars_and_Sense.pdf

This report is the summary of a project led by the Green Building Council of Australia (GBCA) to review the latest international studies and to examine Australian case studies, in an examination of the business case for green commercial buildings in Australia.

Analysis of the Australian Case Study buildings revealed the following key results:

Case Study 1	
Reduction in greenhouse gas emissions	30%
Occupant comfort – are occupants more comfortable?	84% yes[18]
Case Study 2	
Reductions in energy use	70%[19]
Reductions in water use (piped)	82%
Reductions in sewer discharge	72%
Case Study 3	
Addicitional construction costs due to sustainability features	22%
Estimated Payback	11 yrs[20]
Annual savings on running costs	$718,000[21]

The study refers to the most notable studies conducted in the area to date:

- ‘The Costs and Financial Benefits of Green Buildings – A report to California’s Sustainable Building Task Force’ by Greg Kats, October 2003.
- ‘Costing Green: A Comprehensive Cost Database and Budgeting Methodology’ (Langdon report) by Davis Langdon, July 2004.
- ‘A Business Case for Green Buildings in Canada’ (‘Canadian report’) by Mark Lucuik, March 2005.
- The Royal Institution of Chartered Surveyors (RICS report), UK, released ‘Green Value – Green Buildings, Growing Assets’ October 2005.

The report attempts to deal with the question of to whom these benefits/savings accrue, and references “The Insiders Guide to Marketing Green Buildings’ with the following quote:

“with the price of oil rising dramatically and the prospect of peak period electricity prices zooming up again, it just makes good sense to design the most energy-efficient building possible. Even with “triple net” leases in which the tenant pays all the operating costs, it makes sense to offer tenants buildings with the lowest possible operating cost.[22]

The report also quotes a table from the RIC report listing across the top: Green Objectives, Green Initiatives, Green Impact, and Theoretical Value. The Theoretical Value column is an interesting one, particularly if it were to be explored in an effort to apply actual benefits to ideas such as “risk reduction”, “lower tenant turnover” and “positive publicity”.

[18] 64% of whom say it’s because it’s a new building; 64% say because of overall indoor environment conditions
[19] Over conventional office buildings
[20] Conservatively. They believe 8 years is more likely.
[21] Resulting from a reduction in electricity consumption (-85%) gas consumption (-87%) and absenteeism (-1%) with an increase in productivity equivalent to $200,000 PA.
[22] Yudelson (Jerry). Published by Green Building Marketing, November 2004, page137.

***Building Performance Evaluation (BPE) Project*. Evaluation Reports for Buildings "A" through "F".** EcoSmart Foundation, 2006.
http://www.ecosmart.ca/index.cfm?pk=3
The Building Performance Evaluation (BPE) Pilot Study in 2006 was conducted by the EcoSmart Foundation and was an evaluation of six buildings within 1 to 5 years of using a new protocol developed for post-occupancy evaluation of buildings. The protocol assesses the following aspects of a building: energy and water consumption; thermal comfort; acoustics; indoor air quality; and lighting. The BPE Protocol also includes an occupant satisfaction component, which uses the Indoor Environment Quality survey developed by the Centre for the Built Environment (CBE) at University of California at Berkeley.

The primary purpose of BPE is "to improve design practice and ensure the continuous improvement of design methods, through the provision of feedback to designers on the effectiveness of their design choices. BPE is also useful to property managers, building operators, and building occupants, as its collation of detailed measurements and occupant feedback highlight which building features are operating optimally, and which features have the potential to be enhanced."[23]

Building A
Building A is a large office building, however, only three floors were assessed based on a recent renovation. The building renovation was executed using a traditional process that was enhanced by frequent meetings between architect and mechanical engineer. Key goals for the final occupied building included: reduced energy consumption, maximized access to daylight, optimal thermal comfort, a high quality acoustic environment, and optimal indoor air quality, leading to a LEED® CI certification.

Results of the BPE revealed that the building utilizes 30% less energy than the average office building in British Columbia and has an occupant satisfaction rating higher than the average[24].

Building B
Building B is a large office building in the Greater Vancouver Area, occupied by a single organization of 600 people. An integrated design process (IDP) was used during design of the building to produce a cost-effective design based on the following key goals: reduced energy consumption (30% below ASHRAE 90.1-1989), maximized access to daylight, optimal thermal comfort, a high quality acoustic environment, and optimal indoor air quality.

Results of the BPE revealed that the building utilizes more energy than had been previously modeled, yet was 8% below the average BC building. The occupancy survey used in this case study was a pre-existing PROBE survey, and revealed that the occupants were satisfied with the building overall, but expressed desire for more natural light and less glare.

Building C
Building C is LEED® Gold certified and in the Greater Vancouver Area. An integrated design process (IDP) was used during design of the building with the following key goals: reduced energy and water consumption, maximized access to daylight, occupant satisfaction through thermal comfort, a high quality acoustic environment, and optimal indoor air quality.

[23] EcoSmart Foundation. "Building Performance Evaluation (BPE) Project: Evaluation Report for Building A", page B-1.
[24] based on the CBE Indoor Environment data of over 31,000 responses in 240 buildings.

Results of the BPE revealed that the building occupants were generally satisfied with the building, with highest satisfaction in areas of workspace, office layout and furnishings. Occupants gave neutral ratings to the air quality and cleanliness/maintenance of the building (lower than CBE average) and slightly negative ratings to thermal comfort (also below the CBE benchmark). Air quality concerns may be attributed to exterior pollution sources and the presence of operable windows; lack of full cooling of the building may be the source of dissatisfaction with respect to thermal comfort. Lack of quantitative data prohibited the analysis of the energy and water consumption, though it would appear that the implemented measures are effective.

Building D
Building D is LEED® Gold certified and is a small office building housing thirty-six occupants located in the Greater Vancouver Area. An integrated design process (IDP) was used during design of the building with the following key goals: reduced energy and water consumption, maximized access to daylight, thermal comfort through passive systems, a high quality acoustic environment, and optimal indoor air quality.

Results of the BPE revealed that the building occupants were highly satisfied with the building, with acoustic quality as the only parameter receiving a neutral rating. Lack of quantitative data prohibited the analysis of the energy consumption of the building, though it would appear that the implemented measures are effective. Water consumption measured in the building is very close to the predicted consumption.

Building E
Building E is a prominent sustainable university building in Ontario housing offices and lecture theatres, and was designed and constructed prior to the establishment of the LEED® system. An integrated design process (IDP) was used during design of the building with the following key goals: energy and load reduction (50% below ASHRAE 90.1-1989); maximized access to daylight; thermal comfort through larger temperature ranges in transition spaces; a high quality acoustic environment; and optimal indoor air quality.

Results of the BPE revealed that the energy consumption of Building E was 39% below the provincial average for commercial and institutional buildings, and water consumption is one third of the baseline estimated water requirements[25]. The building rated below average or average in the occupant satisfaction survey, with above average ratings in air quality, office layout and furnishings[26].

Building F
Building F is LEED® Silver building housing labs and offices located in the Greater Vancouver Area. The building was designed as a shell, that tenants would "fit-out". An integrated design process (IDP) was used during design of the building with the following key goals: energy savings (25% below the MNECB baseline); reduced water consumption; access to daylight; thermal comfort through larger temperature ranges in transition spaces; a high quality acoustic environment; and optimized indoor air quality.

Results of the BPE revealed that the energy consumption of Building F was 25% lower than a similar building across the street - actual water consumption in 2005 was even lower than predicted. Occupants were generally satisfied with the building, though only 19% of invited responses were received.

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[25] 76 L/occupant/day, American Society of Plumbing Engineers (ASPE)
[26] Only 14% of invited responses obtained compared to a target of 50%.

Energy Efficiency in Buildings: Business Realities and Opportunities. World Business Council for Sustainable Development (WBCSD), 2007.
http://www.wbcsd.org/DocRoot/UZxMnH1c1poU0uEhAm4P/EEB_Facts_Trends.pdf
This report summarizes Year 1 of the Energy Efficiency in Buildings (EEB) project, a project sponsored by the World Business Council for Sustainable Development. The report identifies several challenges inherent in energy efficiency programs, including financial barriers, and behavioural/organizational challenges, and proposes preliminary approaches to addressing them. These high-level approaches will be developed in the next phase of the project with the intent that the project will culminate in commitments to action by project and building sector stakeholders. Table 1 from the study is posted below and outlines effective policy instruments.

	Effectiveness for emission reductions	Cost effectiveness
Control and regulatory instruments		
Appliance standards	High	High
Mandatory labeling & certification programs	High	High
Energy efficiency obligations & quotas	High	High
Utility demand-side management programs	High	High
Economic and market-based instruments		
Energy performance contracting	High	Medium-high
Fiscal instruments and incentives		
Tax exemptions and reductions	High	High
Support, information and voluntary action		
Voluntary certification and labeling	Medium-high	High
Public leadership programs	Medium-high	High

Table 1: Effective policy instruments

"Levers for change"
The report acknowledges that regulation and policy are a needed for the market to be effective, and suggest that if this scenario is given, "*there are three broad business levers that can help remove the barriers to building energy efficiency:*

- **Adopt a holistic approach**. This is essential to integrate individual technologies and innovations.
- **Make energy in buildings more valued** by developing incentives, new commercial relationships and financial mechanisms, and clearer information about building energy performance.
- **Educate and motivate building professionals** and users in order to encourage behaviors that will respond more readily to market opportunities and maximize the potential of existing technology."[27]

Policy and Regulation
Numerous types of policy and regulatory instruments can be used to bring about market changes; governments should focus on those that are most effective at bringing about a reduction in emissions, while remaining cost-effective.

[27] WBCSD. "*Energy Efficiency in Buildings: Business realities and opportunities*", Page 31.

European Green City. Cenergia Energy and Green City Denmark, 2007.
http://www.managenergy.net/download/nr121.pdf
European Green City was a project sponsored by EU-Thermie, which focused on large-scale urban renewal plans and new buildings in eleven European cities. The objective of this project was to implement and evaluate solar low-energy designs using best available technology, and a "total economy approach", with the intent that these designs might generate a realistic market for sustainable and energy efficient buildings.

The technologies utilized included increased insulation, solar heating (passive, DHW, SW), heating systems, mechanical ventilation and controls/meters. While complex in combination, but result in energy savings of 40-60% for heating and domestic hot water, and a 30-35% reduction in electrical and water consumption.

The extra costs per dwelling for the energy saving technologies varied between roughly €4,000 and €16,000 (avg. €9,400), with resultant savings differing significantly with a maximum 70% reduction at the Belgium site.

Simple payback method was used to analyze the investments at the eleven sites, and found that two of the projects had a payback of ten years, while the other projects had longer payback periods. It was also discovered that the most economically attractive investments were project specific, due to widely differing costs from country to country.

Green Building in North America: Background Papers - Draft Summaries. Commission for Environmental Cooperation (CEC), 2007.
http://www.cec.org/files/pdf//GB-PaperSummaries_en.pdf
This report summarizes four draft background papers prepared for the CEC's *Green Building in North America: Opportunities and Challenges* initiative.

Green Building Scenarios for 2030
The intent of this report is to project future building performance in North America based on an "aggressive but achievable uptake of green building practice" with respect to both new construction and renovation, based on the AIA-RAIC Challenge, which proposes a fossil fuel reduction standard for all new buildings, relative to existing stock:

- 60% in 2010
- 70% in 2015
- 80% in 2020
- 90% in 2025
- Carbon-neutral by 2030 (using no net fossil-fuel, GHG-emitting energy to operate)

The report summarizes modeling conducted for both the residential and commercial/institutional building sectors in Canada, Mexico and the United States, which results in a scenario for achieving these targets.

Working Towards Green Building: Financing and Market Consolidation
Green building must be driven by the business case in order for a significant shift towards sustainability to occur. To this end, the report sees environmental value as something that must become a core consideration; changes to the practice of valuation and accounting to recognize the value of the environment will assist in the profit motivation for green building.

Institutional Efforts for Green Building
Some key recommendations from this report are as follows:

- Increase the scope of codes' areas of concern to include full impacts of construction
- Remove regulatory barriers to green building
- Use life cycle analysis and performance based assessment to increase the understanding of voluntary ratings system scores and their impacts on the environment.
- Increase the use of non-tax incentives to green building. These may include expedited permits/density bonuses/other.
- Mandate better information for consumers.
- Measure actual performance
- Promote voluntary standards that are initially ambitious and are continually reviewed to raise performance targets.

Working Towards Accessible and Sustainable Housing
This paper reviews green housing initiatives in North America, looking specifically to propose strategies aimed at promoting sustainable residential construction in this context.

This report recommends numerous strategies, including the adoption of a shared vision across North America, leveraging sharing information and experiences across jurisdictions and to steer housing rules towards environmental stewardship, and to undertake awareness campaigns promoting green building technologies.

Costing Green: A Comprehensive Cost Database and Budgeting Methodology.
Lisa Fay Matthiessen and Peter Morris, Davis Langdon Group, July 2004.
http://www.usgbc.org/Docs/Resources/Cost_of_Green_Full.pdf
This study examines the costs of green buildings compared to non-green buildings. It presents a budgeting methodology that reconciles green measures and technologies with program requirements and client expectations. The report focuses exclusively on construction costs which, in the authors' experience, ultimately drive decisions about sustainable design. Important insights from the study include:

In order to align your budget with your program you must:

- *Understand your starting budget.*
- *Generate a cost model for the project to understand where costs lie.*
- *Allocate funds.*
- *Address limitations in the budget at the Program stage.*
- *It is the choices made during design which will ultimately whether a building can be made sustainable, not the budget set.*

The Cost and Benefit of Achieving Green Buildings. Davis Langdon Group, 2007. http://www.davislangdon.com/upload/StaticFiles/AUSNZ%20Publications/Info%20Data/InfoData_Green_Buildings.pdf

This report is a summary of some of Davis Langdon Group's ongoing research into green buildings. They have researched emerging design strategies used to achieve Green Star ratings, and the financial implications of achieving these ratings. Their research has led to the following observations based on a building greater than 15,000 m^2 NLA:

- The initial impact on construction costs of green buildings is likely in the order of 3-5% for a 5-Star rating.
- This equates to a $98/m2 GFA, requiring an additional gross lease rental of $19/m2 NLA/pa to achieve an 11% IRR.
- For a 6-Star (non-iconic design), the impact is a further 5+% to the construction costs, resulting in $40/m2 NLA/pa.
- 5-Star solutions tend to be approached either by energy reduction or water reduction strategies.
- 6-Star solutions need to consider a combined energy and water reduction approach.
- Increasing fuel/water prices and carbon emissions trading will make an impact on Green thinking.

Consolidated view of the impact on the gross lease rental

Explanatory note: The compounding financial benefit of each Green component offsets the apparent gross lease increase

The Cost of Green Revisited. Lisa Fay Matthiessen and Peter Morris, Davis Langdon Group, 2007.
http://www.davislangdon.com/upload/images/publications/USA/The%20Cost%20of%20Green%20Revisited.pdf

This report is an update to previous research done by the Davis Langdon Group. The main work of the study was to compare the construction costs of buildings whose designers had LEED certification as a primary goal with similar buildings where LEED was not considered during the design. This comparison considered 221 buildings, 83 of which were designed with LEED certification in mind, and the analysis was broken down by building type: Academic Buildings, Laboratory Buildings, Library Buildings, Community Centers and Ambulatory Care Facilities.

The general conclusions derived from this comparison were as follows:

- There is a very large variation in costs of buildings, even within the same building program category.
- Cost differences between buildings are due primarily to program type.
- There are low cost and high cost green buildings.
- There are low cost and high cost non-green buildings.

The overall conclusion was that this was not a meaningful comparison.

Analysis of initial budgets concluded that green can typically be obtained within the original budget of the project however, this budget may or may not have already taken "green" into account. [28]

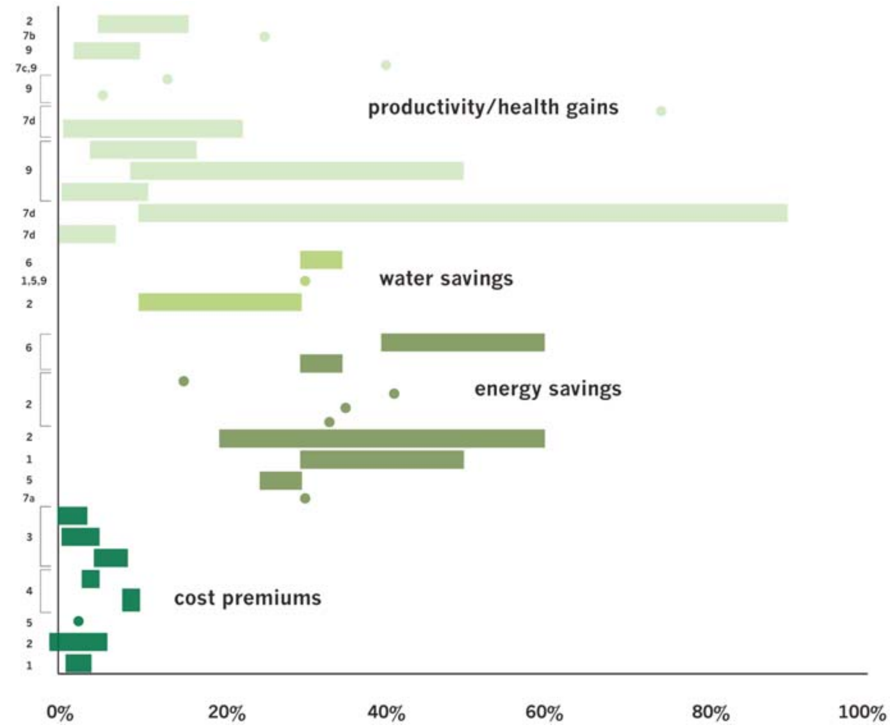
The remainder of the report deals with the feasibility and costs of the LEED points, going through each point individually. For each, there is a short discussion of feasibility and occasionally an associated cost. There is also a short descriptive section on budgeting for green buildings.

Summary of Green Development Costs and Benefits

The findings of the various studies reviewed in this section of the report have been graphically summarized in Figure 2 on the following page. Looking beyond the specific information conveyed on this graph, it can be seen that in exchange for a relatively small investment toward intelligent, integrated design and construction, significant benefits in terms of energy and water conservation are achieved. As importantly, the productivity and well being of occupants is greatly enhanced. The cost premium associated with green development is a one-time-only investment that yields additional benefits in terms of marketing status, improved durability and provision of a buffer against spiraling energy prices.

Further to the studies reviewed in this section of the report, there is also the potential for green development to help avoid infrastructure costs. Potable water, sewage and stormwater systems, solid waste management and electrical energy generation infrastructure are not required to expand as much and as quickly to accommodate green economic growth and development, compared to conventional practices. Comprehensive studies of avoided costs due to green development were not encountered during the literature review conducted within this study, however, there is a growing body of research relating intensification and smart growth to decreased reliance of the automobile, hence improved urban air quality and energy resource conservation.

[28] Not including specific sustainable features such as photovoltaics.



1 A Blueprint for Green Building Economics, David Gottfried. *Environmental Design + Construction* (2003).
2 [Energy and Water savings as cost]
Green Building Can Make Financial Sense. Alan Scott and Bruce Wood. Land Development Today (May 2005).
3 [0%-3.5% (LEED Silver); 0.5%-5% (LEED Gold); 4.5% - 8.5% (LEED Platinum)]
Managing the Cost of Green Buildings: K-12 Public Schools, Research Laboratories, Public Libraries, Multi-family Affordable Housing. Geof Syphers, et al. (October 2003).
4 [3-5% 5-Star +5% for 6 star]
The cost & benefit of achieving Green buildings. Davis Langdon Group (2007).
5 [2% average premium]
The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force. Gregory H. Kats et. al. (2003).
6 [40-60% heating; 30-35% electrical]
European Green City. Cenergia & Green City Denmark (2001).
7 Green Buildings and the Bottom Line, *Building Design and Construction*. Reed Business Information (2006).
- a [30% decrease in energy use/sf - industrial case study]
- b [25% increase in productivity - industrial case study]
- c [40% increase in retail sales from daylighting. from Heschong Mahone study of daylighting's impact on retail sales]
- d [74% decrease in headaches from ballast replacement with electronic.]
Review of studies related to health and human benefi ts of green buildings by Carnegie Mellon University led by Vivian Loftness, FAIA, and Volker Hartkopf, PhD.
- e [0.7 to 23% increase in productivity from improved lighting design.]
Review of studies related to health and human benefits of green buildings by Carnegie Mellon University led by Vivian Loftness, FAIA, and Volker Hartkopf, PhD.
- f [10 to 90% decrease in respiratory illness from high performance ventilation systems.]
Review of studies related to health and human benefits of green buildings by Carnegie Mellon University led by Vivian Loftness, FAIA, and Volker Hartkopf, PhD.
- g [0.2 to 7% increase in performance from temperature control.]
Review of studies related to health and human benefits of green buildings by Carnegie Mellon University led by Vivian Loftness, FAIA, and Volker Hartkopf, PhD.

8 [SCHOOLS: 15% (lighting controls); 41% (conditioning of outside air). OFFICE: 35% (load responsive HVAC design). RETAIL: 33% (improved lighting design.)Avg. Energy cost savings per category.]
High Performance Building Design in Minnesota. The Weidt Group for the Minnesota Office of Environmental Assistance (2005).
9 A Business Case for Green Buildings in Canada. Mark Lucuik, Morrison Hershfield. (2005).
- a 40% increase in retail sales from daylighting
- b 13% increase in productivity from daylighting
- c 5% increase in test scores from daylighting
- d 4 to 17% increase in productivity from increased ventilation
- e 9 to 50% decrease in productivity from better quality ventilation
- f 0.5 to 11% in productivity from increased ventilation control

Figure 2. Summary of costs and benefits associated with green buildings.

A review of the cost-benefit studies summarized earlier in this section of the report reveals the following significant findings and relationships:

- Virtually all of the studies reviewed focus on green buildings and have not discussed the full economic, social and environmental costs and benefits associated with green development.
- Economic valuation of biodiversity suffers from the same disadvantage faced by green development – the measures are simplistic, monetary and fail to consider externalities and irreversible impacts. No ecology means no economy.
- Building occupants are highly aware of and positively responsive to green building features, particularly as they relate to enhanced indoor environmental quality. Productivity gains and health benefits must be measured and economically assessed in terms of avoided costs. Health, productivity and public relations benefits are just as important to the bottom line as improved energy efficiency and water conservation.
- The reduction of construction and demolition waste through the adoption of green building practices contributes significantly to solid waste management programs, resource conservation and pollution abatement.
- Intelligent, integrated design and informed decision making can deliver green buildings at or below the cost of conventional buildings. Willingness to pay is a more critical consideration than affordability, except for the low income segment of the population. Green building costs can be effectively managed and cost premiums can be largely dampened through market-based incentives.
- Studies indicate that developers reap fewer life cycle benefits from green buildings than consumers, utilities and municipalities and this must be recognized in any system that seeks to advance equitable green development policies.
- Building performance evaluations indicate that most of the promises of occupied green buildings are realized, but often inconsistently. There remains a genuine need for post-occupancy evaluations and the public reporting of actual versus predicted energy and water use.
- Performance labeling (energy, water, etc.) through mandatory certification programs for all buildings, remains among the most effective mechanisms for reducing the environmental impacts of buildings, and differentiating green buildings in the marketplace.
- Based on the diffusion rates for building technology, and the high proportion of existing buildings to new building construction, it is feasible for new green buildings to cost effectively approach a carbon-neutral energy target by 2030, requiring no net greenhouse gas generating energy to operate. New developments should also become net zero impact communities, exerting no net burden on municipal infrastructure and utilities by 2030.

In 2006, Canada's gross domestic product (GDP) was approximately $1.45 trillion, and the construction and development industry accounted for about $74 billion.[29] Domestic expenditure on research and development (R&D) totaled $28.07 billion, about 1.94% of the GDP.[30] Business enterprises accounted for just over half the total R&D expenditures, investing $15.77 billion.[31] The construction and development industry does not appear in any R&D statistics, but if this $74 billion a year industry had invested at the national average rate for R&D in 2006, some $1.4 billion in funding would have been available. The costs and benefits reported herein are based on an industry employing a 20th century business model. It is reasonable to expect that similar gains in cost effectiveness enjoyed by other industry sectors could be realized by the green development industry through appropriate R&D investments.

> *Green Development Economics*
> *"Brands will not be able to opt out of [being green]. Companies which do not live by a green protocol will be financially damaged because consumers will punish them. In the longer term, I do not think they will survive. Yet the window of opportunity is closing: soon green will simply be a threshold to compete. Moreover, it takes time to build green credentials that consumers deem authentic. Companies that do not actively pursue a green brand strategy today risk being left behind."*
>
> **Lee Daley**, chairman and chief executive of Saatchi & Saatchi

[29] Statistics Canada http://www40.statcan.ca/l01/cst01/econ41.htm
[30] Statistics Canada http://www40.statcan.ca/l01/cst01/scte03.htm
[31] Statistics Canada http://www40.statcan.ca/l01/cst01/econ151a.htm

Economic Cost-Benefit Assessment Methods

Cost-benefit analyses attempt to compare the costs and benefits associated with alternative decisions involving policies, technologies and investments using economic measures. The economic measures employed in this cost-benefit study are familiar to economists and financiers involved in investment decisions. This section is aimed at assisting non-expert readers of this report appreciate the meaning and limitations of the various measures. Economic measures used in this study are based on *ASTM Standards on Building Economics*[32], and selected to reflect the economic perspectives of key stakeholders.

The various perspectives that are brought to bear on investments in urban development require careful consideration if the results obtained from analyses are to prove useful to stakeholders. For building developments in general, there exist three major perspectives to be considered, corresponding to the key stakeholders: developers/builders; consumers (owners and tenants); and society (government).

Developers and/or builders, are primarily concerned with first costs, sometimes referred to as capital costs, and how these affect the profitability of their business enterprise. The carrying costs and opportunity costs associated with higher first costs must result in substantial benefits, both short term (marketability) and long term (reduced callbacks and complaints), if this stakeholder is to elect better practices such as green development. Typically, developers look at cost effectiveness through a measure termed *internal rate of return* (IRR). In the case of deciding between business-as-usual (BAU) and green development, developers often want to know if they will obtain at least the same rate of return on the additional costs invested for green development as for the BAU case. This is not always the sole deciding factor. Where green development is more marketable and enhances the developer's reputation, there may be a tradeoff between timely sale or lease versus a lower rate of return. Regardless, there is usually a minimum acceptable rate of return below which it is not feasible to operate a development enterprise.

Consumers of buildings are generally more interested in affordability, especially for housing. Affordability relates the cost of securing adequate and suitable building real estate at a cost that does not place an unreasonable financial burden on a household, institution or business enterprise. It involves the costs of ownership including operating energy, upkeep and insurance. Generally, consumers are averse to improvements in buildings that negatively impact affordability, unless these arise in response to matters of health and safety, now taken to include issues such as climate change and indoor air quality. The most common economic measure employed by consumers is termed *simple payback* (SPB). They are interested to know how long it will take savings from investments in green technologies, such as energy conservation, to payback their additional cost.

The societal perspective on investments in building technology is generally long term, taken over the useful life of the buildings. The primary concern is the viability of the building over its life cycle and how to maximize this benefit across all of society. A societal perspective implies that buildings are viewed more like natural and cultural resources, not simply as commodities, hence they must be conserved for succeeding generations. The construction of new buildings commits society to supply many forms of energy and services, on demand, for the useful life of the building (typically 75 years, plus). Roads, bridges, schools, hospitals, fire and police stations are among the many investments that society must make to support new development. Where building development exceeds the capacity of existing infrastructure, an escalation in the cost of municipal services normally results. The societal commitment to servicing new building development and dealing with all forms of effluent (storm water,

[32] *ASTM Standards on Building Economics*, Sixth Edition, 2007. American Society for Testing and Materials.

sewage, products of combustion, etc.) must be economically assessed to properly compare between different standards of performance for parameters such as density, diversity, and energy and water efficiency. This sort of comprehensive assessment is beyond the scope of this study, which focuses on new building development within the context of the Toronto Green Development Standard as it is presently proposed. However, it is reasonable to expect the standard may evolve to include existing communities as well as new development, and comprehensively consider not only the direct impacts of new development, but also the indirect impacts associated with issues like transportation, infrastructure, social and health services.

Economic costs and benefits along with environmental impacts are normally the issues that take on a societal importance with respect to building technology, particularly within the context of green development. This assessment is knowingly confined to direct impacts and it is appreciated that the true costs and benefits of investments in building technology cannot really be disaggregated from the entire economic, social and environmental cost-benefit matrix. Societal decision makers are gradually adopting the life cycle cost measure to assess the cost effectiveness of green development measures. In its simplest form, the life cycle cost is expressed as a *net present value* (NPV) of all the costs associated with a particular proposal, which is then compared between alternatives. The lowest life cycle cost usually represents the best investment from a societal perspective, provided the non-monetary considerations are similar among competing alternatives.

Perspective	Investment or Improvement	Study Period	Economic Measure
Developer/Builder	Technology exceeding minimum health and safety (code) requirements	Commencement of construction to time of sale (1 to 2 years, typically)	Internal Rate of Return (IRR)
Consumer	Discretionary, depreciable and non-depreciable improvements	Expected period for benefits to exceed costs (3 to 10 years, typically)	Simple Payback (SPB) or Payback (PB)
Societal	All investments	Service life of building system, including envelope, equipment, fixtures and finishes (50 to 100 years, typically)	Life Cycle Cost (LCC) using Modified Uniform Present Worth (MUPW)

The term *discretionary improvements* refers to any measures which exceed minimum requirements for health and safety, whereas *non-discretionary investments* refer to any available measures needed to comply with minimum requirements for health and safety. From a consumer perspective, a *depreciable* item is one with a service life that is less than the duration of tenure or mortgage, whereas a *non-depreciable* item does not significantly depreciate during this period.

Table 4. Economic measures corresponding to key stakeholder perspectives.

These stakeholder perspectives are summarized in Table 4. The discussion that follows briefly presents each economic measure of costs and benefits and how these reflect the economic perspective of key stakeholders. Readers should appreciate that while these measures involve more sophisticated analytical techniques than are normally employed in day-to-day marketplace transactions, they remain limited in their ability to fully reflect the economic complexity of building development.

Internal Rate of Return Measure

In this study, the internal rate of return (IRR) measure is applied according to the method set out in the corresponding ASTM standard on building economics.[33] Traditionally the IRR measure has been used in finance and economics to measure the percentage yield on investments. The yields from various investments are compared to determine the most attractive investment alternative.

Consider the case where a person is asked to spend an additional $1,000 on a high efficiency furnace that will save them $100 annually in energy costs. If the discount or interest rate is 4% and the price of heating energy is escalating at an annual rate of 8%, the internal rate of return is 8% over a 10-year period, and 16.4% over a 20-year period. But when the escalation rate is 10% and the discount or interest rate is 4%, the internal rate of return is 10% over a 10-year period, and 18.5% over a 20-year period. The bigger the differential between the discount rate and the energy price escalation rate, and the longer the period over which this differential yields a return, the more attractive are investments in energy conservation. Key issues to resolve when using the IRR measure are the relationship between the discount and escalation rates, and the period over which the IRR is calculated. The assessment of a 10-year and a 20-year period for the previous example resulted in a significant difference between IRR measures, and this is a more critical consideration than the difference between the discount and escalation rates for short to medium term time periods. Normally, the time period should correspond to the useful life of the component or equipment to which a cost premium (additional investment) is being applied. For building envelopes, 50 years is commonly used as a representative study period based on observed service life of façade materials and components. In the case of heating, ventilating and air-conditioning (HVAC) equipment, 25 years is typically set as a reasonable study period. It is assumed the HVAC equipment will be replaced at that time an another cost-benefit assessment will be performed to select the most attractive alternative.

Looking at the previous example from a developer/builder perspective, the internal rate of return on the additional $1,000 invested in the high efficiency furnace should be similar to the regular return rate on invested funds. For example, if the developer/builder normally sees a 15% return on their investments, then a comparable return on energy conservation would require that they pay no more than an $870 premium for a high efficiency furnace they could sell to the consumer for $1,000.

Internal Rate of Return

$$PVNB = \sum_{t=0}^{N} \frac{(B_t - \bar{C}_t)}{(1 + i^*)^t} = 0$$

where:

PVNB = present value of net benefits (or, if applied to a cost reducing investment, present value of net savings).

N = number of discounting periods in the study period.

B_t = dollar value of benefits in period *t* for the alternative evaluated less the counterpart benefits in period *t* for the mutually exclusive alternative against which it is compared.

$\bar{C}_t$ = dollar costs, excluding investment costs, in period *t* for the alternative evaluated less the counterpart costs in period *t* for the mutually exclusive alternative against which it is compared.

i^* = interest rate for which PVNB = 0, that is, the IRR measure expressed as a decimal.

Figure 3. Formula used in calculating the internal rate of return measure.

[33] ASTM E 1057 Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems.

Simple Payback and Payback Measures

In this study, the simple payback and payback measures have been calculated according to the equations in Figure 5, taken from the corresponding ASTM standard[34]. Simple payback assumes there is no significant difference between the discount rate (interest rate) and the escalation rate (for example, the rate at which energy prices increase each year). Under the simple payback measure, if a person is asked to spend an additional $1,000 on a high efficiency furnace that will save them $100 annually in energy costs, this method would indicate a payback period of $1000/$100 per year = 10 years. But when the escalation rate for energy is higher than the discount or interest rate, it takes less time than calculated by the simple payback method to breakeven on the additional investment of $1,000. When the energy price escalation rate is 8% and the discount rate is 4%, the payback period is 8.35 years. The payback period falls to 7.76 years when the escalation rate is 10% and the discount rate is 4%.

Simple Payback

$$SPB = C_o/(B - \tilde{C})$$

where:

- SPB = period of time, expressed in years, over which investments are recovered to the breakeven point
- C_o = dollar value of initial investment costs, as of the base time.
- $(B - \tilde{C})$ = initial value of an annual, uniformly escalating, net cash flow

Payback

when e is not equal to i:

$$PB = \frac{\log\left[1 + (SPB)(1 - (1 + i)/(1 + e))\right]}{\log\left[(1 + e)/(1 + i)\right]}$$

where:

- PB = period of time, expressed in years, over which investments are recovered to the breakeven point
- i = discount rate
- e = escalation rate

SPB = PB when e is equal to i.

Figure 5. Formulas corresponding to the simple payback and payback measures.

It is interesting to note that in Table 4, the normally expected payback period sought by consumers is in the range of 3 to10 years. This range is based on a series of studies conducted mostly during the 1980s.[35,36,37] There have been few, if any, comprehensive studies of consumer attitudes towards acceptable payback periods on investments in energy efficiency performed in the last decade. By contrast, the highest return on investment is attained when the time period corresponds to the useful life of the investment, in this case approximately 20 years for the high efficiency furnace. This points to a possible disconnect between consumer attitudes toward payback period and rates of return on investments in energy conservation. Clearly, as the cost of energy climbs the return on the additional cost invested in the energy conserving technology (furnace) improves. Perhaps consumers are really saying they want to recover their investment quickly and then continue to enjoy their savings for a long time afterwards. Breaking even while saving the environment does not appear to hold significant appeal as a socially desirable economic perspective on the consumption of green development products and services.

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[34] ASTM E 1121 Measuring Payback for Investments in Buildings and Building Systems.

[35] The Market Needs Help: The Disappointing Record of Home Energy Conservation. Bernard J. Frieden, Kermit Baker, *Journal of Policy Analysis and Management*, Vol. 2, No. 3 (Spring, 1983), pp. 432-448.

[36] Testing the Social Involvement Model in an Energy Conservation Context. B. Freiden and K. Downs, *Journal of the Academy of Marketing Science*, 1986; 14: 13-20.

[37] Review of Government and Utility Energy Conservation Programs. J Clinton, H Geller, and E Hirst. Annual Review of Energy, Vol. 11: 95-142, November 1986.

Life Cycle Costing

Life cycle economic assessments attempt to monetize various alternatives to compare their cost effectiveness. This approach normally involves estimating life cycle costs according to procedures outlined in the corresponding ASTM standard[38]. The most common methods of calculating life cycle costs involve the use of the *uniform present worth* (UPW) and *modified uniform present worth* (MUPW) measures, as noted in Figure 6. Under this approach, for a given life cycle period, all of the annual costs (or savings) are converted into a present worth using time-value of money economics.

Modified Uniform Present Worth

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

Uniform Present Worth

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

where:

- P = present sum of money.
- A = end-of-period payment (or receipt) in a uniform series of payments (or receipts) over N periods at i interest or discount rate.
- A_o = initial value of a periodic payment (receipt) evaluated at the beginning of the study period.
- N = number of interest or discount periods.
- i = interest or discount rate.
- e = price escalation rate per period.

Figure 6. Formulas corresponding to the modified uniform present worth and uniform present worth measures.

For example, how much money would an individual have to set aside today to pay for all of their home energy bills until s/he sells the home at retirement? This will depend on how much interest the lump sum of money set aside earns, but also the rate at which the price of energy increases. Investments in buildings may be treated in a similar fashion. By adding the capital cost of a building to the present worth of its predicted life cycle operating energy costs, meaningful comparisons among alternatives may be considered.

Returning to the example of the high efficiency furnace, life cycle costing may be applied to the minimum efficiency furnace permitted under current codes and standards, and then to the high efficiency furnace. The most cost effective alternative could then be determined. Similarly, the minimum standard furnace could be arbitrarily assigned a base life cycle cost of zero, and then the life cycle savings or costs associated with the high efficiency furnace compared accordingly.

For a discount rate of 4% and an energy price escalation rate of 8%, the 20-year life cycle energy savings have a net present value of $3,043. The life cycle savings of the high efficiency furnace over the minimum efficiency furnace are $2,043 ($3,043 - $1,000). Setting the discount and escalation rates to 4% and 10%, respectively, yields a 20-year life cycle savings of $2,796. Increasing the study period to 25 years (assuming a useful service life of 25 years for the high efficiency furnace), the life cycle savings for the two previous cases are $3,236 and $4,618, respectively. These estimates assume that the maintenance costs and useful service life are similar for both furnaces.

[38] ASTM E 917 Measuring Life Cycle Costs of Buildings and Building Systems.

From a societal perspective, the investment in energy conservation (cost premium for the high efficiency gas furnace) could have ranged from $2,043 to $2,796 more than the $1,000 cost premium, assuming a 20-year life cycle period, and it would still be considered as cost effective as the minimum standard. From a consumer perspective, investing $2,043 to $2,796 more than the $1,000 cost premium would also be seen as equally cost effective, provided the higher price did not affect affordability. This is a real concern for housing where mortgage eligibility normally reflects the purchase price only – investments in green building features, such as energy conservation, are not considered differently by most financial institutions.

Relationship Between Interest Rates and Energy Price Escalation Rates
The modified uniform present worth formula has only recently been favoured by energy efficiency analysts over the uniform present worth formula that does not differentiate between the discount or interest rate and the energy price escalation rate. Figure 7 depicts the present value of savings for an initial annual savings of $100 over a range of study periods and several discount and escalation rates.

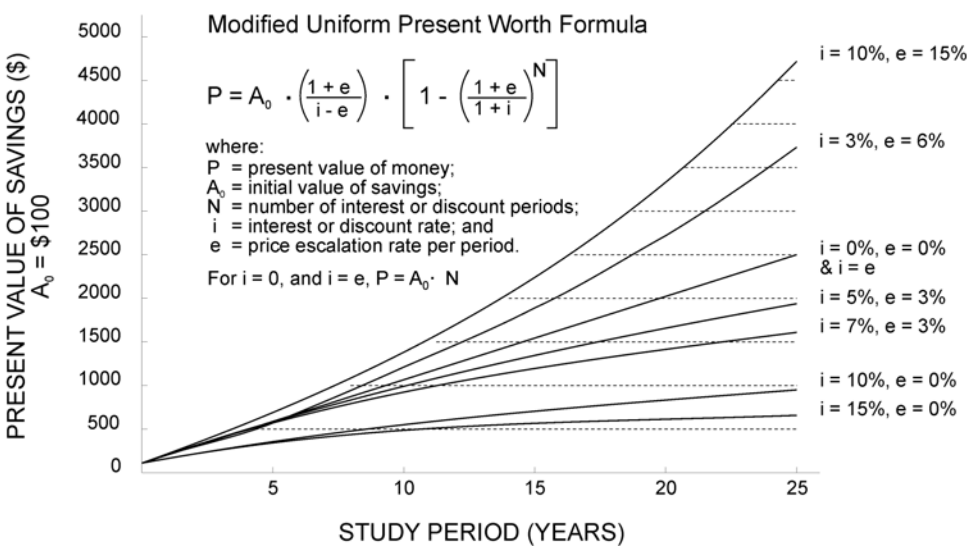

Figure 7. Sensitivity of modified uniform present worth measure to differences between the discount (interest) and energy price escalation rates.

Based on Figure 7, the following observations may be noted:

1. When interest rates are high, and the escalation rate of energy is low, investments in energy efficiency are not encouraging. Put simply, it is better to invest the money and earn more from interest than can be saved from energy efficiency improvements.
2. When the interest rate and the escalation rate are the same, the relationship is purely linear and there is not a preferred alternative.
3. When the escalation rate of energy exceeds the interest rate, investments in energy efficiency are very attractive - especially over long time periods. An investment that saves $100 in annual energy costs (as depicted above) has a present worth of nearly $4,800 when the interest rate and escalation rate differ by 5% over a 25-year study period. In other words, it is cost effective to invest almost $4,800 today to save $100 annually over the next 25 years under this economic scenario.

Life cycle costing may be more easily understood by way of an example that involves frequent expenditures on energy and fluctuating energy prices.

Life Cycle Costing Example

The use of the modified present worth measure of life cycle cost effectiveness is best illustrated through a comparative example – in this case involving automobiles. In order to objectively compare between the life cycle cost of two vehicle options, the purchase price and cost of fuel over 7 years of ownership are assessed. Auto A is a conventional vehicle, and Auto B is a fuel-efficient hybrid vehicle. It is assumed each vehicle is driven for 20,000 kilometers annually.

Life Cycle Parameters

Two interest rate and fuel escalation rate scenarios are considered in the analysis.

The cars are assumed to be owned for a 7-year period, then traded in or sold.

	Current	*High*
Interest	4.0%	6.0%
Escalation	8.0%	12.0%
Period	7 years	7 years

			Present Worth of Fuel		***Present Worth of Car + Fuel***	
	Purchase Price	**Annual Fuel**	***Current***	***High***	***Current***	***High***
Auto A	$28,350	$1,380	$11,266	$12,113	$39,616	$40,463
Auto B	$31,250	$900	$7,347	$7,900	$38,597	$39,150

Table 5. Example life cycle cost comparison between two automobiles.

If an automobile owner wished to pay for all 7 years of fuel consumption at the time of purchasing the vehicle, the fuel for Auto A would cost $11,266 under the current scenario and $12,113 under the high fuel price escalation scenario. For Auto A, the present value of the 7 years of fuel would be $7,347 and $7,900 respectively.

Based on this present worth analysis, and taking into account both the purchase price and fuel costs, Auto A is more cost effective when the fuel price escalation rate remains at the current levels over the next 7 years. In reality, the hybrid car qualifies for a rebate which makes it a better deal. Under the high price scenario, which is currently forecast by most energy economists over the next 7 years, Auto B is the more cost effective investment, and even more so when the rebate is taken into consideration.

There are some notable observations regarding the use of life cycle costing. First, it is a measure that is not favoured by sales and marketing forces because it has a discouraging effect on the consumer. Imagine if every automobile price tag listed the estimated life cycle cost of $40,463 versus $28,350. Second, there are many costs that may not appear in life cycle costing if they are equal among alternatives. In the example above, the cost of licenses, insurance, maintenance and repairs has not been included because they are considered roughly equivalent. When these are applied at approximately $8,000 per year for the typical Canadian car, the present value, or life cycle cost, to the consumer of Auto A becomes about $56,000. This is almost two times the sticker price of the automobile.

How does life cycle operating energy compare to the cost of buildings? For typical new buildings, looking at a 25-year study period, comparable to a typical mortgage, energy costs account for between 30% to 50% of the total life cycle cost. From the consumer's perspective, accounting for 25 years of energy use is like adding one-third to one-half of the selling or leasing cost to the mortgage. This amount can vary substantially depending on the escalation rate of energy prices over the next 25 years making the situation similar to having a mortgage where the principal owing is annually adjusted to reflect market prices.

The preceding discussion has attempted to present how the various economic measures are employed in cost-benefit analyses of green development versus business-as-usual practices. All of the measures carry a certain degree of uncertainty due to our inability to predict the future. What will energy prices be in 25 years? Will energy conservation be an issue in 50 or 75 years, or will we have invented technologies for inexpensively generating all the clean energy we need to operate our communities, buildings and automobiles? Is it possible that people inhabiting the Greater Toronto Area and Hamilton will be sufficiently affluent, relative to the rest of the world, such that only non-economic measures such as quality of life will matter?

It is premature to assume there exists a broad social consensus on appropriate yardsticks for measuring the costs and benefits of green development. Sustainability is a recently re-discovered concept for the average person and there remain sharp differences in opinions among bona fide experts in the field of sustainable development as how to best measure alternative approaches to addressing the economic, social and environmental bottom lines. In this study, traditional economic measures have been applied to aspects of green development that can be monetized, such as energy and water conservation. Cultural, social and emotional factors are difficult to assess and remain largely beyond the scope of this study. This does not suggest they are unimportant, but simply that we are not at a stage of evolution where we have collectively agreed upon a means of reconciling measures among multi-dimensional phenomena that are related to often contradictory aspirations. Economic measures, such as those presented in this and subsequent sections of the study, remain the only yardsticks, however limited, where the units of measure (dollars) are common to everyone.

…policy makers should be more aware that carbon reduction targets will rely on individuals using energy efficiently and those individuals operate in a social context and the influence of cultural, social and emotional influences cannot be underestimated. To that end, it would appear that the issue of learning and awareness, coupled with accessibility to simple technologies would be a central factor to formulating effective policy.

***Towards a contemporary approach for understanding consumer behaviour in the context of domestic energy use**. Adam Faiers, Matt Cook and Charles Neame. Energy Policy 35 (2007) 4381–4390.*

Building Energy Conservation Measures

This section of the report examines the cost effectiveness of energy conservation measures in buildings - a primary environmental driver behind the TGDS that seeks to improve energy efficiency and reduce greenhouse gas emissions. Building energy efficiency is examined separately for several reasons:

- Buildings in Canada account for approximately 30.1% of total energy consumption[39], and contribute to about 28.6% of total greenhouse gas emissions[40];
- For developers, buildings typically represent the largest expenditure compared to other aspects of urban development such as land costs, servicing and development charges, hence the cost effectiveness of energy conservation measures is a critical consideration; and
- For consumers of buildings, either purchase or rental, energy costs are becoming a more significant consideration, in some cases affecting affordability or economic competitiveness.

"Although a comprehensive approach to environmental performance is desirable, greenhouse gas mitigation through increased energy efficiency should be considered a priority environmental goal."

Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products.

The form of building development is not examined in this section of the report, fully acknowledging that compact and intensive communities tend to consume less energy and generate lower greenhouse gas emissions due to reduced reliance on the automobile. While the automobile and its growing use due to urban sprawl may appear to be more significant than urban development in terms of greenhouse gas emissions, air pollution and environmental degradation, there is an important difference between automobiles and buildings. Automobiles have a useful life in the range of a decade, hence technological innovations to reduce their ecological footprint can rapidly displace obsolete technologies. The diffusion of "green" automotive technologies will be rapid and widely accessible compared to the built form. Buildings, besides costing many times more than a typical automobile, have a useful life in the range of a century, and cannot be as easily disposed, in favour of more innovative and efficient technologies. According to 2006 census data, there were 2,186,730 occupied private dwellings in the Greater Toronto Area and Hamilton (GTAH).[41] Another 40,591 commercial and institutional buildings were estimated for the GTAH in 2000.[42] Since then, $29.67 billion in building permits for commercial and institutional buildings have been reported from 2001 to 2006. The vast majority of these buildings are not energy efficient.

Inferior quality buildings and supporting infrastructure represent long-term future economic and environmental burdens. The cost of avoidance is significantly less than the cost of repair, retrofit or replacement. Urban form and density are strong determinants of transportation choices, but it will be far easier and less disruptive to reduce the ecological footprint of the transportation sector than to retrofit our building stock and municipal infrastructure. In the case of infrastructure, developers often have less latitude to employ innovative technologies due to standards imposed by municipalities. Cost-effective investments in site infrastructure are discussed later in this report.

[39] *Energy Use Data Handbook Tables*, Table 2. Canada's Secondary Energy Use by Sector, End-Use and Sub-Sector, 1998-2005. Natural Resources Canada.
[40] *Energy Efficiency Trends in Canada, 1990 to 2004*. Office of Energy Efficiency, Natural Resources Canada, 2006.
[41] 2006 Census of Population, Statistics Canada.
[42] *Commercial and Institutional Building Energy Use Survey 2000, Detailed Statistical Report, December 2002*. Office of Energy Efficiency, Natural Resources Canada.

Previous cost-benefit studies have estimated the premium for green buildings, often including measures for the site and services, to range between 3% and 7% of the construction costs. A separate analysis was conducted within this study for buildings constructed in the GTAH to determine if they were consistent with these other estimates. This section focuses on energy efficiency and later in the report, the other components of green development are separately investigated. Before continuing with the cost-benefit analysis of energy conservation measures, some building statistics have been assembled to provide context and perspective.

Building Statistics and Forecasts

The rate of development in the GTAH over the past decade has set numerous records and forecasts indicate a comparable growth rate may continue for several more decades. The importance of the Toronto Green Development Standard can be better appreciated by considering the magnitude of urban development that shall be engaged in the near future. It represents an enormous societal investment that can either be a legacy or a burden to successive generations, depending on its durability and energy efficiency.

From 2006 to 2031, the population of the GTAH is expected to increase by nearly 2.6 million people, or approximately 30%. Over the next quarter century, investments in buildings alone, excluding all infrastructure, are forecast to range from $165.6 billion to $307.6 billion, expressed in 2007 dollars. The implications of constructing energy inefficient buildings are sobering in terms of expenditures on energy, the costs of expanding electrical generating capacity, and increased greenhouse gas emissions.

The Government of Ontario prepared and approved the Places to Grow Act, 2005 which came into effect on June 16, 2006. The government's official plan for growth in the Greater Golden Horseshoe is explained in its *Places to Grow* publication[43]. *Places to Grow* predicts a significant increase in population for the GTAH in the decades between 2001 and 2031. Along with this population growth will come significant investment in construction and infrastructure. Predictions with respect to the magnitude of this construction investment in the GTAH are integral to broadening our understanding of the implications of the Toronto Green Development Standard and its mechanisms for implementation.

As part of the cost-benefit study, an analysis was undertaken to predict on a broad scale the construction investment associated with *Places to Grow* population forecasts, in the areas of residential and non-residential construction. The following data in Table 6 are a summary of this predicted investment data.

Table 6. Forecast Building Permit Values in GTAH 2007-2031 ($000 2007)

Sector/ Building Type	**2001-2006 Actual**	**Forecast Building Permit Values 2007-2031**		
		Low	**Reference**	**High**
Apartments	$9,477,804	$18,991,965	$26,558,255	$35,278,724
Rows	$5,908,310	$11,839,284	$16,555,986	$21,992,186
Doubles	$4,316,304	$8,649,165	$12,094,942	$16,066,347
Singles	$29,378,246	$58,869,186	$82,322,333	$109,353,078
Residential	*$52,963,846*	*$106,130,861*	*$148,412,788*	*$197,144,500*
Commercial	$14,673,970	$29,404,228	$41,118,704	$54,620,134
Institutional/Gov't	$9,284,471	$18,604,557	$26,016,506	$34,559,091
Industrial	$5,712,997	$11,447,909	$16,008,690	$21,265,183
Total Non-Residential	*$29,671,437*	*$59,456,694*	*$83,143,900*	*$110,444,408*
Total	**$82,635,284**	**$165,587,555**	**$231,556,687**	**$307,588,908**

Sources:
2001-2006, Statistics Canada, Table 026-0001 - Building permits, residential values and number of units, by type of dwelling, monthly and Table 026-0003 - Building permits, values by activity sector, monthly
Forecast Data, ***Growth Outlook for Greater Golden Horseshoe***. Hemson Consulting Ltd., January 2005. Appendix A, Table A-4 - population forecasts
Conversion to 2007 dollars, The annual data for 2001-2006 was converted to 2007 dollars using annual Core CPI data from the Bank of Canada.

[43] *Growth Plan for the Greater Golden Horseshoe*. Ontario Ministry of Infrastructure Renewal, 2006.

According to Table 6, over the next quarter century, investments in buildings alone, excluding all infrastructure, are forecast to range from $165.6 billion to $307.6 billion, expressed in 2007 dollars. When all infrastructure and services are factored, the next generation of Canadians living in the GTAH could see more than half a trillion dollars invested in urban development.

Looking at the forecast growth in the number of households forecast in Table 7, roughly between one-half and one million new housing units will be constructed by 2031 in the GTAH. During this period, the population of the GTAH is expected to increase from 6.06 million (2006 Census) to 8.62 million, nearly a 30% increase.

The implications of constructing energy inefficient buildings are sobering in terms of expenditures on energy, the costs of expanding electrical generating capacity, and increased greenhouse gas emissions. Overall impacts on the cost of living and corresponding wage settlements could further diminish the competitiveness of Ontario's manufacturing sector. Reduced disposable income means less money for culture and recreation, adversely impacting quality of life. When viewed through this lens, energy conservation may be seen by many as a necessity, not an option.

Table 7. Forecast Number of Residential Units in GTAH 2007-2031

Unit Type	2001-2006 Actual	Forecast Units 2007-2031		
		Low	Reference	High
Apartments	79,467	159,239	222,679	295,796
Rows	45,577	91,329	127,714	169,649
Doubles	28,196	56,500	79,009	104,952
Singles	132,391	265,290	370,980	492,792
Total	**291,548**	**584,214**	**816,962**	**1,085,214**

Sources:
2001-2006, Table 026-0001 - Building permits, residential values and number of units, by type of dwelling, monthly
Forecast Data, ***Growth Outlook for Greater Golden Horseshoe.*** Hemson Consulting Ltd., January 2005. Appendix A, Table A-4 - population forecasts

Notes on Forecast Methodology
Data Sources
Recent historical data was used as a baseline for the analysis. Raw data was obtained from StatsCan related to residential and non-residential construction as follows:
Table 026-0001 provides monthly statistics on residential building permits.
Building Permit Values, by type of dwelling (apartments, rows, doubles, singles, total)
Number of units, by type of dwelling
Table 026-0003 provides monthly statistics on building permit values by sector.
Building Permit Values, by sector (residential, commercial, institutional & governmental, industrial, total non-residential, total)
Three StatsCan data sets were required to cover the GTAH: Toronto, Hamilton and Oshawa. For the purposes of the analysis, the reference period used was 2001 to 2006. Annual population data for the GTAH regions for 2000 to 2006 was obtained from StatsCan Table 051-0034 to obtain population increase data for the reference period, while population increase projections were obtained from *The Growth Outlook for the Greater Golden Horseshoe*, Hemson Consulting Ltd., January 2005.
Analysis
The building permit data was summarized annually for the GTAH in the above-noted categories; annual population increases were derived from the population data. Once converted to 2007 dollars using annual Core CPI data from the Bank of Canada, these two data sets were integrated to obtain building permit values per increase in population of 1000, for each building permit category. These investment ratios were extrapolated using the population projections from Hemson Consulting Ltd.; the resulting forecasts of construction investment were then summarized for the period of the *Places to Grow* study.

Multi-Unit Residential Buildings (MURBs)

The cost-benefit analysis of energy conservation measures begins with multi-unit residential buildings, in particular, condominiums (condos). This form of building development has become very popular across the Greater Toronto Area & Hamilton (GTAH) and accounts for a significant proportion of new housing within the City of Toronto proper. The following data indicate the condo trend is likely to influence urban development in the GTAH for some time to come.

Over the last twenty five years, condominium apartments have grown from virtual nonexistence to 50% of all new home sales and 15% of all housing resales in the Toronto CMA.
http://www.urbanation.ca/HTML/about.htm

The Toronto area has 249 projects currently being marketed or in the construction stage, representing 58,000 units, making the city the largest condo site in North America, according to consulting research firm Urbanation. And this year is a watershed year: for the first time, condos will likely outsell low-rise homes with a greater than 50 per cent market share.
Condo sales booming. Tony Wong, Toronto Star, November 15, 2007.
http://www.thestar.com/printArticle/276706

The average sale price across the Toronto census area is $371 per square foot, up 10.1% from a year ago. Sale prices have jumped from about $180 per square foot in 1996. It has eaten into affordability. To carry a 700-square-foot apartment - the average size of a unit in the city - a consumer would need about $70,000 in household income, based on a standard mortgage with 25% down. Affordability has eroded quickly after remaining relatively stable for most of the decade. From 2001 to 2005, a buyer needed about $54,000 to $57,000 to carry that same 700-square-foot apartment in Toronto. It climbed to $63,000 by last year, rising another $7,000 this year. Despite the cut in affordability, some of which has been driven by rising interest rates, Ms. Renwick said speculation is hardly rampant. Urbanation said of the 249 projects in the works, it estimates 30% of units were bought by investors. The other 70% of the condos to go up in the next five years will be owner occupied. That 70% is made up of 30% first-time buyers, 20% move-up buyers and 20% people downsizing.
Toronto is North America's condo king: Urbanation. Garry Marr, National Post, November 19, 2007.

Given the surging demand for this type of housing development in the GTAH, the first cost-benefit analysis of energy conservation in buildings examined new condominium towers. The process involved the configuration of a baseline condominium building with characteristics corresponding to the typical new projects advertised for sale. The energy performance of this baseline model was simulated using energy analysis software and then an energy performance workshop was conducted with stakeholders. During this workshop, costing data provided by quantity surveyors was used to price various energy conservation measures. The energy performance of each measure was then estimated in relation to the baseline energy model to determine the payback period, internal rate of return and life cycle cost associated with each measure. Impacts on peak electrical energy demand and annual greenhouse gas emissions were also assessed. A complete set of results and discussion appear in Appendix A of this report.

Baseline MURB Building

The model MURB condo building used for the cost-benefit analysis is depicted in Figure 8. It is a 20-storey building consisting of 18 storeys of residential units above a ground floor retail space and a second floor amenity space (health facilities, recreational and social rooms, etc.). The building contains a total of 250,000 square feet of conditioned space. The suites are conditioned using 2-pipe fan coil units supplied with heated and chilled water on a seasonal basis. An electric resistance heater in each fan coil unit provides supplementary heating. Conventional HVAC systems condition the retail and amenity spaces of the building.

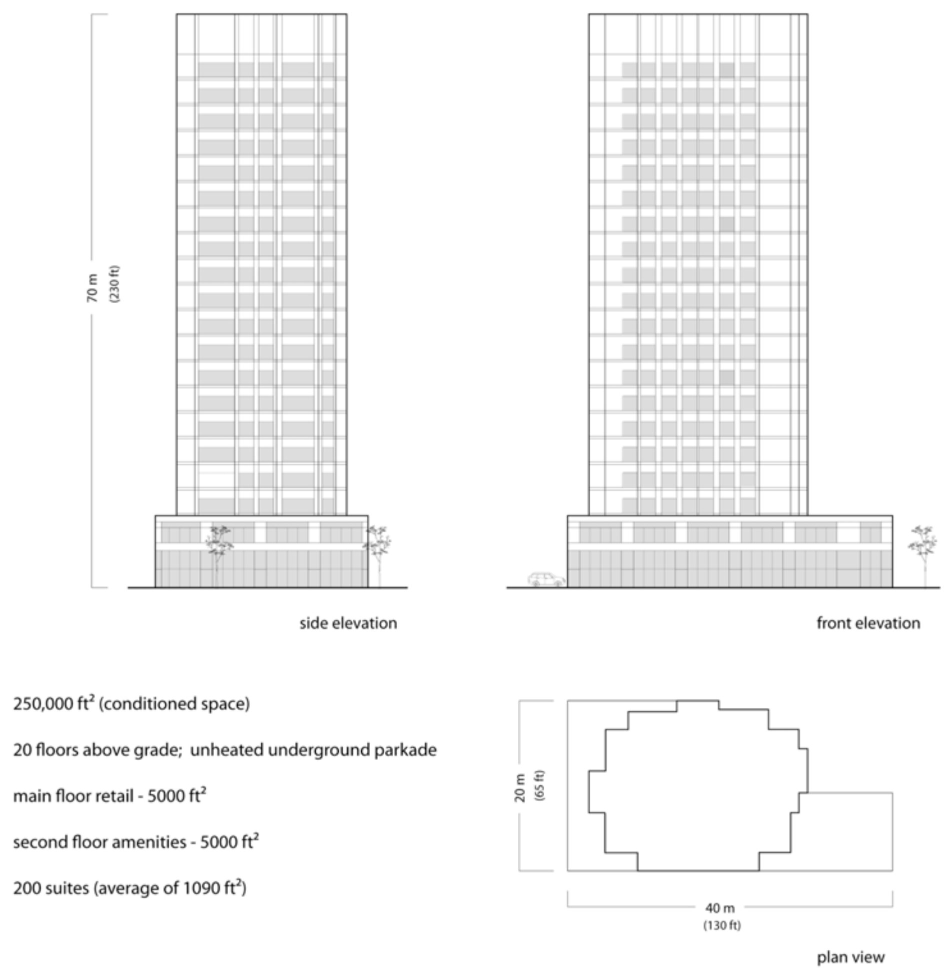

Figure 8. Model MURB building used for energy simulation and cost-benefit assessment.

An interesting development occurred during the MURB condo energy performance workshop. The energy consumption of the baseline building was found to be almost 24% above that needed to comply with energy efficiency requirements of the Ontario Building Code. The Toronto Green Development Standard requires new buildings to be at least 25% more energy efficient than minimum levels prescribed in the Code. In order for many of the typical condominium buildings to comply with the TGDS, their energy consumption would have to be reduced by nearly 50%. It was speculated the main cause of this dramatic difference was due to the erroneous practice, during design and compliance checking, of using nominal thermal resistance values for glazing and spandrel panels instead of the effective thermal resistance values of the entire window wall assemblies. Due to the high level of thermal bridging common in these assemblies, more sophisticated assessment tools such FRAMEplus (http://www.frameplus.ca/) may be more appropriate for use by designers and professionals checking energy efficiency compliance in new buildings. It may be reasonably argued that given concerns about affordability and rising energy prices, proper computer simulation of energy performance should supercede simplified methods that do not effectively capture actual energy costs, and the results made available to prospective condo buyers.

The results of the energy and cost-benefit analyses appear in Table 8. Figure 9 indicates the meaning of the data appearing in Table 8.

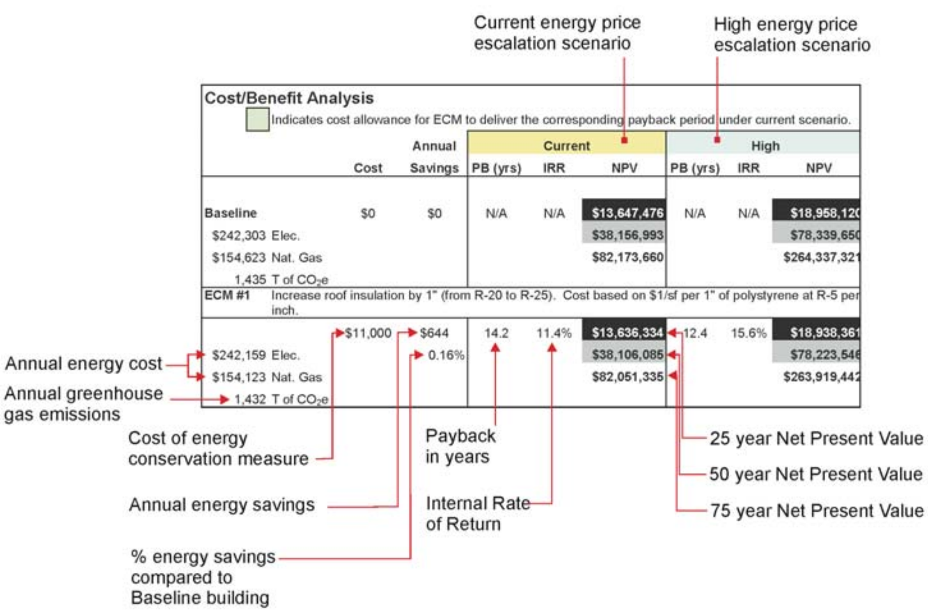

Figure 9. Legend of data appearing in Table 8, energy and economic assessment of energy conservation measures in model MURB building.

Table 8 presents the cost-benefit analysis for 20 energy conservation measures (ECMs) as described therein. Two combinations of energy conservation measures were then bundled into an integrated energy design package and assessed for total system performance.

MURB Energy Conservation Cost-Benefit Analysis

Further to the discussion presented in the preceding section on economic cost-benefit assessment methods, the analyses presented in Table 8 are based on two interest (discount) rate and energy price escalation rate scenarios. The current scenario assumes an interest rate of 5.5% and an energy price escalation rate of 8%, similar to what has been witnessed during the past 5 years. A high scenario assumes an interest rate of 7% and an energy price escalation rate of 12%, which effectively sees Ontario energy prices approaching world prices over the next 25 years.

The baseline building was estimated to have an annual energy cost of $396,926 and generate 1,435 tonnes of greenhouse gas emissions (CO_2 equivalent). As a baseline building, by definition the payback period and internal rate of return are not applicable. The net present value (NPV) of the energy costs are indicated for the three study periods of 25, 50 and 75 years, according to the two economic scenarios. Looking at the current scenario, the 25-year net present value is $13,647,476 and this rises to $82,173,660 for a 75-year period. By comparison, under the high scenario, the 25-year net present value is $18,958,120, rising to $264,337,321 for a 75-year period. It is difficult to imagine that the cost of 25 or 75 years of energy expressed in 2007 dollars would reach such high amounts. The influence of the differential between the interest and escalation rates becomes dramatic for the 75-year period. The 25-year net present values represent the energy cost burden to the first generation occupying the baseline building. The 50-year and 75-year net present values reflect possible future burdens for succeeding generations.

Table 8. Multi-Unit Residential Building (MURB) – Energy and Economic Assessment of Energy Conservation Measures

This analysis is based on an energy performance workshop conducted by EnerSys Analytics Inc.
Economic measures based on:
ASTM E 1057 Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems
ASTM E 1121 Measuring Payback for Investments in Buildings and Building Systems
ASTM E 917 Measuring Life Cycle Costs of Buildings and Building Systems

Effects of energy conservation measures (ECMs) on equipment downsizing not considered.

Economic Assessment Parameters

Two interest (discount) rate and energy escalation rate scenarios are considered in this analysis.

	Current	*High*
Interest Rate	**5.5%**	**7.0%**
Energy Escalation Rate	**8.0%**	**12.0%**
Study Period (yrs)	**25**	**25**
	50	**50**
	75	**75**

Cost/Benefit Analysis

Indicates cost allowance for ECM to deliver the corresponding payback period under current scenario.

			Annual	**Current**			**High**		
		Cost	**Savings**	**PB (yrs)**	**IRR**	**NPV**	**PB (yrs)**	**IRR**	**NPV**
Baseline		$0	$0	N/A	N/A	**$13,647,476**	N/A	N/A	**$18,958,120**
$242,303	Elec.					**$38,156,993**			**$78,339,650**
$154,623	Nat. Gas					**$82,173,660**			**$264,337,321**
1,435	T of CO_2e								
ECM #1	Increase roof insulation by 1” (from R-20 to R-25). Cost based on $1/ft2 per 1” of polystyrene at R-5 per inch.								
		$11,000	$644	14.2	11.4%	**$13,636,334**	12.4	15.6%	**$18,938,361**
$242,159	Elec.		0.16%			**$38,106,085**			**$78,223,546**
$154,123	Nat. Gas					**$82,051,335**			**$263,919,442**
1,432	T of CO_2e								

The first energy conservation measure (ECM #1) estimated the impact of increasing the roof insulation level from R-20 (RSI 3.52) to R-25 (RSI 4.40) by adding 1 inch (25 mm) of extruded polystyrene. It is important to note that all of the thermal resistance values used in the analyses are effective thermal resistance values that take into account thermal bridging effects. To achieve an R-20 roof, between R-25 and R-30 nominal insulation levels must be added to the enclosure. The additional insulation is considered to effectively provide its full nominal value. The cost of the additional insulation is $11,000 and it reduces the annual energy costs by $644, greenhouse gas emissions by 3 tonnes. The measure yields a payback period of 14.2 years and an internal rate of return of 11.4% under the current scenario, 12.4 years and 15.6% under the high scenario.

Looking at the 25-year net present value under the current scenario, the difference between ECM#1 and the Baseline building is $11,142. This means the added roof insulation could have cost $22,142 ($11,000 + $11,142) and it would be just as cost effective over a 25-year period as the lower level of roof insulation. The difference increases to $30,759 ($11,000 + $19,759) under the high energy price escalation rate scenario. This indicates that if the 25-year net present value was used as a basis for assessing cost effectiveness, instead of payback or internal rate of return measures, greater levels of energy efficiency and greenhouse gas reductions could be achieved.

ECM #2	Improve glazing type and frame quality (better thermal break) to provide for a 27% U-value improvement (to Uo=0.4). Assume a lower shading coefficient at SC-0.55 from SC-0.69. The better framing system improves the spandrel R-value from about R-5 to R-7.								
		$450,000	$23,916	15.4	10.5%	**$13,275,174**	13.4	14.6%	**$18,265,835**
$236,068	Elec.		6.03%			**$36,307,918**			**$74,069,447**
$136,942	Nat. Gas					**$77,672,446**			**$248,860,193**
1,332	T of CO_2e								
ECM #3	Previous measure (ECM-2), plus adding 1" continuous rigid insulation to masonry walls to improve R-value from about R-10 to R-15, at an extra cost of $15,000.								
		$465,000	$25,896	14.8	10.9%	**$13,222,096**	12.9	15.1%	**$18,186,266**
$235,798	Elec.		6.52%			**$36,132,578**			**$73,693,663**
$135,232	Nat. Gas					**$77,277,537**			**$247,556,589**
1,322	T of CO_2e								
ECM #4	Improved wall system (ECM-3), but with glazing reduced from 60% to 50% at an estimated cost reduction of $90,000 for the reduction in glazing.								
		$375,000	$33,907	9.7	16.2%	**$12,856,655**	8.8	20.5%	**$17,713,641**
$229,401	Elec.		8.54%			**$35,272,471**			**$72,022,565**
$133,618	Nat. Gas					**$75,529,058**			**$242,131,574**
1,297	T of CO_2e								
ECM #5	Improved wall system (ECM-3), but with glazing reduced from 60% to 40% at an estimated cost reduction of $175,000 for the reduction in glazing.								
		$290,000	$42,779	6.2	23.4%	**$12,466,609**	5.8	27.9%	**$17,204,894**
$223,015	Elec.		10.78%			**$34,334,594**			**$70,186,535**
$131,132	Nat. Gas					**$73,607,331**			**$236,138,166**
1,266	T of CO_2e								
ECM #6	Wall configuration for ECM-5 but with 80% masonry and 20% spandrel for opaque wall area, for an overall R-value of 12.2. Incremental capital costs based on replacing 28,000 sf of spandrel with masonry wall at $10/sf.								
		$570,000	$45,608	10.8	14.7%	**$12,649,340**	9.7	19.0%	**$17,349,774**
$222,629	Elec.		11.49%			**$34,342,639**			**$69,908,186**
$128,689	Nat. Gas					**$73,301,657**			**$234,534,162**
1,253	T of CO_2e								
ECM #7	Add $1.5 million for a 3/4-element Visionwall™ or equivalent upgrade to window/spandrel system to capital costs from ECM-5. Improves U-value to about Uo-0.2 and conservatively increases spandrel by another R-1.								
		$1,790,000	$64,138	21.3	7.1%	**$13,232,224**	17.7	11.1%	**$17,684,738**
$218,880	Elec.		16.16%			**$33,781,327**			**$67,470,997**
$113,908	Nat. Gas					**$70,685,481**			**$223,413,901**
1,171	T of CO_2e								

A number of improvements to building envelope thermal efficiency are indicated in ECMs #2 to #7, inclusive. Based on the cost-benefit measures, all of the ECMs are cost effective, however, there is a wide range of payback periods and rates of return. One of the observations that emerged from varying the glazing area in ECMs #4 and #5 is that both the initial costs and operating costs can be reduced by modestly reducing the window areas in condominium developments. This also renders the installation of better performing glazing systems more affordable. ECM #7 examines the installation of an exceptionally high performance glazing system and under both energy price escalation scenarios, it may be considered cost effective. The useful service life of the glazing system exceeds the payback periods and offers attractive rates of return compared to prevailing interest rates. When assessed on the basis of life cycle costs over a 25-year period, savings of $412,252 are realized under the current scenario and $1,273,382 assuming the high energy price escalation scenario.

ECM #8	Consider selecting glazing with better shading coefficient for east and west sides to control peak cooling loads (i.e., about a 10% reduction).								
		$68,000	$1,975	25.0	5.5%	**$13,647,570**	20.4	9.4%	**$18,931,789**
$236,720	Elec.		0.50%			**$38,035,134**			**$78,017,852**
$158,231	Nat. Gas					**$81,832,785**			**$263,090,048**
1,437	T of CO_2e								
ECM #9	Sensitivity to show the energy savings from adding 2.5' overhangs on all windows, although most of the savings come from overhangs on south-facing windows. Peak cooling loads are reduced by over 9%.								
		$166,500	$4,839	25.0	5.5%	**$13,647,597**	20.4	9.4%	**$18,893,498**
$234,895	Elec.		1.22%			**$37,858,314**			**$77,551,096**
$157,192	Nat. Gas					**$81,338,365**			**$261,281,235**
1,427	T of CO_2e								
ECM #10	Combined effect of reducing the shading coefficient on east and west windows (ECM-8) and adding overhangs to all windows (ECM-9).								
		$234,500	$6,815	25.0	5.5%	**$13,647,657**	20.4	9.4%	**$18,867,119**
$229,311	Elec.		1.72%			**$37,736,359**			**$77,229,101**
$160,800	Nat. Gas					**$80,997,283**			**$260,033,295**
1,429	T of CO_2e								

ECMs #8, 9 & 10 examine changes to shading coefficients for the glazing and the use of overhangs to provide shading. These assessments were intended to determine how much of a cost premium could be carried if the energy savings delivered a 25-year payback period under the current energy price escalation scenario. Currently, selection of alternative shading coefficients can be accommodated within the $68,000 allowance, but the cost allowance for shading devices added to the building as an overhang element is insufficient, representing about half the price of current systems. The shading provided by cantilevered balconies in earlier MURB typologies would provide comparable energy savings during the cooling season, however, these would be countered by thermal bridging during the heating season. Self-shading building designs were not examined.

Improvements to the energy efficiency of lighting are examined in ECMs #11, 12 and 13. Occupancy sensors controlling a part of the suite lighting are cost effective provided higher quality sensors with a longer service life are selected. Installing lighting fixtures that only accept compact fluorescent bulbs is also a cost effective measure. Underground parking garage light sensors were estimated to provide very attractive payback periods and rates of return due to the reduction in the proportion of fixtures operating continuously on a 24-hour basis.

ECM #11	Install occupancy sensors for 20% of the suite lighting. Capital costs based on $35 per sensor for higher quality sensors (x 200 suites x 3 rooms per suite). The cheapest sensor/switches have a lifespan of 4-5 years but the more expensive sensors are estimated to last 10 years.								
		$21,000	$2,135	8.8	11.1%	**$13,595,069**	8.0	16.7%	**$18,877,147**
$239,587	Elec.		0.54%			**$37,972,753**			**$77,939,273**
$155,204	Nat. Gas					**$81,752,661**			**$262,936,494**
1,430	T of CO_2e								
ECM #12	Replace 45% of suite incandescent lighting with compact fluorescent bulbs. Capital costs based on $500 per suite for installed fixtures.								
		$100,000	$11,210	8.0	19.0%	**$13,362,044**	7.3	23.5%	**$18,522,704**
$228,043	Elec.		2.82%			**$37,179,362**			**$76,227,178**
$157,673	Nat. Gas					**$79,952,908**			**$256,971,896**
1,410	T of CO_2e								
ECM #13	This measure represents installing 66 lighting occupancy sensors in the parking garage at $150 per sensor (~1000 ft2 per sensor).								
		$10,000	$6,119	1.8	65.3%	**$13,447,087**	1.5	72.2%	**$18,675,862**
$236,117	Elec.		1.54%			**$37,578,766**			**$77,141,968**
$154,690	Nat. Gas					**$80,916,873**			**$260,272,304**
1,418	T of CO_2e								

The deployment of heat recovery ventilators (HRVs) serving each suite was found to be a reasonably cost effective energy conservation measure. The improved ventilation effectiveness of this technology compared to conventional systems' reliance on ventilation air seeping into suites from pressurized hallways could not be monetized, and the scheduling of the HRV operations was also not taken into account. In MURB type buildings, the ventilation system operates continuously whereas occupants would likely shut off their HRVs when their suites are not occupied and ventilation is not required. This diversity factor was not applied to the modeling of HRVs hence their cost effectiveness is somewhat underestimated.

Central reverse-flow heat recovery was found to be more cost effective than individual HRVs. Economy of scale permits investments in very high efficiency technology and practically 100% of the ventilation air passes through the heat recovery stream. In general, heat recovery was found to deliver payback periods and rates of return that were considered not only acceptable but attractive to all stakeholders.

ECM #14	In-suite HRV units offset 80% of the outside air originally provided by the make-up air units via the interior corridor, at an overall effectiveness of 60%. Note that indoor air quality should improve as most of the fresh air is provided directly to suites instead of via corridors.								
		$200,000	$23,835	7.6	19.9%	**$13,027,959**	7.0	24.4%	**$18,019,704**
$247,395	Elec.		6.00%			**$36,065,705**			**$73,835,434**
$125,696	Nat. Gas					**$77,439,215**			**$248,664,136**
1,308	T of CO_2e								
ECM #15	Central reverse-flow 90% effective heat recovery with all exhaust ducted back to make-up air unit. Capital costs based on $10 per cfm, plus an extra $50,000 for ductwork.								
		$250,000	$40,781	5.7	25.2%	**$12,495,306**	5.3	29.8%	**$17,260,323**
$256,728	Elec.		10.27%			**$34,486,665**			**$70,540,872**
$99,417	Nat. Gas					**$73,980,967**			**$237,428,757**
1,206	T of CO_2e								

HVAC systems were examined in ECMs #16 to #20. Condensing boilers and low-flow plumbing fixtures were found to be very cost effective measures. It is worth noting that the cost premium allowance for low flow plumbing fixtures of $64,500 was derived by assuming a 7-year payback period under the current energy price escalation scenario. It is unlikely so large a premium would be incurred by this measure, hence higher cost effectiveness would likely be realized.

Improvements to cooling system efficiency are reasonably cost effective, but the most cost effective improvement to the entire mechanical system involved the deployment of variable speed drives on the heating/cooling system circulation pumps. Conventional circulation pumps operate at a single high speed continuously whereas variable speed drive pumps modulate according to the demand for heating and cooling. The energy savings support attractive payback periods and rates of return.

The cost effectiveness of switching to a partial ground source heat pump (GSHP) system remains questionable. The payback periods would likely be higher when the repair and replacement of compressors is taken into account. The influence of time-of-use electricity rates is also difficult to predict. While it was not assessed, this technology has been identified as highly cost effective where natural gas is not available.

ECM #16	Condensing boilers at an estimated incremental cost of $10/MBH.								
		$80,000	$33,976	2.3	53.9%	**$12,559,282**	2.2	59.6%	**$17,415,346**
$242,303	Elec.		8.56%			**$34,970,838**			**$71,713,946**
$120,647	Nat. Gas					**$75,219,773**			**$241,790,623**
1,269	T of CO_2e								
ECM #17	Low-flow domestic hot water fixtures (1.5 gpm shower heads and 1.0 gpm faucets) may have no extra incremental cost for an equivalent quality. Estimated savings of about 25% versus plumbing code (2.5 gpm shower heads and 2.2 gpm faucets).								
		$64,500	$8,378	7.0	21.3%	**$13,423,916**	6.5	25.7%	**$18,622,467**
$242,303	Elec.		2.11%			**$37,416,106**			**$76,750,618**
$146,245	Nat. Gas					**$80,503,703**			**$258,822,398**
1,394	T of CO_2e								
ECM #18	Roughly estimate an improvement of 10% on the overall cooling system efficiency. Capital costs based on $10/MBH.								
		$25,000	$1,142	17.5	9.1%	**$13,633,211**	14.9	13.2%	**$18,928,575**
$241,161	Elec.		0.29%			**$38,072,211**			**$78,139,258**
$154,623	Nat. Gas					**$81,962,237**			**$263,601,793**
1,432	T of CO_2e								
ECM #19	Variable speed drives on two-pipe pumping system to optimize flow in heating and cooling mode. Capital costs may be low, but even if they are an order of magnitude higher, the ECM is cost-effective.								
		$2,500	$30,599	0.1	1329.9%	**$12,597,893**	0.1	1382.8 %	**$17,499,139**
$203,601	Elec.		7.71%			**$35,217,973**			**$72,302,951**
$162,726	Nat. Gas					**$75,841,397**			**$243,962,074**
1,366	T of CO_2e								
ECM #20	Savings from a 170-ton partial ground-source heat pump system, sized to meet 50% of the peak heating load but at least 90% of the annual heating needs. Capital costs based on $4000 per ton.								
		$680,000	$25,381	20.6	7.4%	**$13,454,803**	17.2	11.4%	**$18,425,863**
$312,260	Elec.		6.39%			**$36,397,086**			**$74,010,306**
$59,285	Nat. Gas					**$77,599,155**			**$248,114,559**
1,168	T of CO_2e								

Finally, two combinations of energy conservation measures were assembled and their energy performance simulated. Combo A was assembled by taking the most cost effective individual measures discussed previously. Combo B is the same as Combo A, but with a 50% glazing area instead of 40%. The payback periods and rates of return for both buildings are attractive, especially under the high energy price escalation rate scenario. Combo B permits a fuller architectural expression of the glazing without significantly affecting performance. It is important to note that beyond the 50% glazing area threshold, it is difficult to attain significant reductions in energy consumption for almost all types of buildings. This understanding is beginning to emerge as green building design encounters rating systems, such as LEED or Green Globes, where energy efficiency credits are determined by computer modeling. Experience shows that limiting glazing areas is critical to attaining high levels of energy efficiency in a cold climate.

Combo A	ECM #5 + ECM #13 + ECM #14 + ECM #16 +ECM #17 +ECM #19.								
		$862,500	$134,000	6.0	24.2%	**$9,902,665**	5.5	28.8%	**$13,420,464**
$181,630	Elec.		33.76%			**$26,137,906**			**$52,755,122**
$81,296	Nat. Gas					**$55,294,791**			**$175,961,018**
906	T of CO_2e								
Combo B	Combo A but with 50% glazing (ECM #4).								
		$952,500	$127,631	6.8	21.7%	**$10,211,649**	6.3	26.2%	**$13,814,663**
$184,718	Elec.		32.15%			**$26,840,165**			**$54,102,145**
$84,577	Nat. Gas					**$56,703,334**			**$180,292,525**
931	T of CO_2e								

Beyond payback periods and rates of return, the discussion of integrated building systems turns to an examination of life cycle costs. From a societal perspective, as well the consumer perspective assuming a 25-year mortgage, the NPV difference under the current scenario between a conventional condominium building and one that consumes about one-third less energy is $3,744,811 for Combo A and $3,435,827 for Combo B, including the cost premium. In other words, the energy conservation measures upgrade would have been as cost effective as the conventional system if it had cost some $3.7 million more for Combo A and $3.43 million more for Combo B. Based on life cycle costing, the energy savings support a substantially larger cost premium for Combo A in the range of $14.98 per ft^2 under the current energy price escalation rate scenario and $22.15 per ft^2 under the high scenario. For Combo B the range is $13.74 per ft^2 under the current scenario, and $20.57 per ft^2 under the high scenario. This level of additional investment could afford an even greater level of energy efficiency and improved durability than the upgrades for Combos A and B now provide. Energy economics alone justify substantially higher investments in building fabric and HVAC systems that are highly cost effective and greatly reduce the ecological footprint of new developments.

Looking at energy conservation measures from the perspective of the owner of a typical 700 square foot suite, and averaging between Combo A and B costs and savings, for an additional cost of $2,541 for a unit with an average sale price of $259,700 (700 ft^2 @ $371/ft^2), the owner can save $368 per year for a payback of 6 years and an internal rate of return of 22.3% assuming the current scenario; 5.7 years and 24.6% respectively, assuming the high energy price escalation rate scenario. The difference in 25-year net present values between a conventional baseline condo and an energy efficient model is $24,740 for the current scenario and $33,638 for the high scenario. This would easily pay for an even higher performing building envelope and HVAC system, both in terms of energy efficiency and durability, than the one assumed in the upgraded combos. An important factor emerging from life cycle analysis is the need to reconcile justifiably higher initial costs with mortgage eligibility. Clearly, the energy savings can finance the higher initial costs however, this economic relationship must be acknowledged by financial institutions and mortgage insurance agencies through their policies and practices.

Important Note:
Savings through HVAC downsizing made possible due to improvements in the energy efficiency of the building envelope were not factored into the cost-benefit analysis for MURB condos. Energy performance workshop participants agreed that typically the design of condo HVAC systems did not employ sufficiently sophisticated techniques to account for related energy efficiency improvements. As a result, the cost premiums for the ECMs tend to be higher than would be the case if HVAC systems were sized accordingly.

Time-of-use rates for electricity have not been accounted for in this cost-benefit study. It is reasonable to assume that with their introduction, the operating energy costs will be higher as will the life cycle energy costs. This effectively means that cost-benefit relationships examined in this study will tend to conservatively estimate the benefits associated with energy conservation measures.

Table 9. Multi-Unit Residential Building (High-Rise Condo) Statistics

Building Areas	ft^2	m^2	***Building Envelope***	ft^2	m^2
Gross Floor Area	250,000	23,238	Roof Area	10,900	1,013
Main Floor Retail	5,000	465	Gross Wall Area	87,000	8,087
2nd Floor Amenity	5,000	465	Opaque Wall Area	35,000	3,253
			Window Area	52,000	4,833
			Percent Glazing	60%	60%

Note: Combo A has 40% glazing and Combo B has 50% glazing.

Energy & Conservation Measure Data

	Annual Energy Intensity		**Annual Energy Costs**		**Cost Premium**	
	BTU/ ft^2	kWhe/ m^2	$/ ft^2	$/ m^2	$/ ft^2	$/ m^2
Baseline Building	85900	271	$1.59	$17.09	$0.00	$0.00
Combo A	51900	164	$1.05	$11.32	$3.45	$37.12
Combo B	53500	169	$1.08	$11.59	$3.81	$40.99

	GHG Emissions			**Peak Electricity Demand Reductions (kW)**		**Avoided Costs**
	Tonnes	Reduction	%	Max	%	@ $1,500/kW
Baseline Building	1,435	0	0	0.0	0.0%	0
Combo A	906	529	36.9%	127.0	18.6%	$190,500
Combo B	931	504	35.1%	108.0	15.9%	$162,000

Baseline peak demands - Heating 237.2 kW (October), Cooling 374.9 kW (July), Max 681 kW (July)

Table 9 provides summary statistics from the cost-benefit analysis of the MURB condo building model. The annual energy intensities of Combos A and B are 39.5% and 37.6 % lower, respectively, than the baseline building. The annual energy costs are correspondingly lower on a unit area basis, adjusting for HVAC system efficiency. The cost premiums associated with the energy conservation measures for Combos A and B are $3.45 per ft^2 and $3.81 per ft^2 respectively. As was noted earlier, based on life cycle costing, the energy savings support a substantially improved construction budget for Combo A in the range of $14.98 per ft^2 under the current energy price escalation rate scenario and $22.15 per ft^2 under the high scenario. Combo B can economically support a cost premium of $13.74 per ft^2 under the current energy price escalation scenario, and $20.57 per ft^2 under the high scenario.

Greenhouse gas emissions are 36.9% lower for Combo A and 35.1% lower for Combo B compared to the baseline building. The valuation of greenhouse gas emissions has not been assessed but reductions may provide significant revenues under a cap and trade system.

Another significant economic impact of energy conservation measures is the avoided costs associated with peak electrical energy demand reductions. These avoided costs represent significant societal savings that can be used to address other needs or pursue more sustainable opportunities.

In this study, it proved difficult to obtain simple estimates of developing new electrical energy generation capacity in Ontario. Costs vary depending on the fuel type (renewables versus nuclear, fossil fuel, etc.) and the sophistication of the technology (e.g., simple-cycle versus combined-cycle versus combined heat and power). In the most recent source of information obtained, it was estimated that the lowest capital cost to construct new electrical energy generation capacity in response to peak demand was $1,500 per kW. An earlier study cited a cost of $1,600 per kW[44], but it remains uncertain if these costs also factor in the cost of transmission and distribution.

According to the OPA, the capital cost of 1,350 MW of simple-cycle generation is $898 million and these new power plants will be only operated for 2.5% of the year. That is, the OPA is recommending that the province invest almost $900 million to build new, inefficient power plants simply to meet the spike in electricity demand that occurs between noon and 6 p.m. on the hottest summer days when our air-conditioners are running full out.
The Ontario Power Authority's Coal Power Phase-Out Strategy: A Critical Review.
Ontario Clean Air Alliance, September 24, 2007.
http://www.cleanairalliance.org/resource/phase%20out%20strategy%20review.pdf

Based on these costs, the energy conservation measures taken in Combo A reduce peak electricity demand by 127 kW and avoid a cost of $190,500 to the utility. Combo B reduces peak demand by 108 kW and avoids a cost of $162,000. These avoided costs represent 22.1% and 17.0 % of the cost premium associated with Combo A and B, respectively.

The amount of incentives for reducing the peak electrical energy demand in new buildings remains a subject of debate in Ontario. On one side, it has been argued the incentive should reflect the full cost of additional generating capacity because this is actually less than the historical costs of building new generating capacity due to budget overruns. Another side argues that peak demand should be priced such that reduction measures are more cost effective than paying demand charges that reflect the real costs. Regardless of the position taken toward incentives, there is general agreement that insufficient resources are being directed toward conservation and demand management. A recent study compares spending on expanding electrical energy supply versus conservation, and indicates a large imbalance in favour of expansion.[45] If energy conservation and demand management avoid expansion costs, reduce greenhouse gas reductions and improve housing affordability, it puts into question the uneven investment of public funds in electrical energy generating technologies that do not provide similar benefits.

[44] *Letting Everyone Help: Removing Barriers to Consumer Participation in Energy Conservation*. Public Interest Advocacy Centre, Ottawa, February 2006.
[45] Ontario Clean Air Alliance, a published in *A Quick-Start Energy Strategy for Ontario*, Pembina Institute, April 2006.
http://pubs.pembina.org/reports/quickstart_Final_Apr0606.pdf

This investment imbalance is coupled to questionable assumptions regarding future electrical energy demands. Figure 10 depicts 3 phases of electricity consumption in Ontario. The gross provincial product (GPP) per kilowatt-hour of electricity consumption is plotted in the upper chart, and indicates that since 1993 there has been a considerable improvement in electricity productivity. The lower chart shows that had the ratio of GPP to consumption remained at the 1994 level throughout the period, the electricity demand in 2003 would have exceeded 200,000 GWh – 50,000 GWh higher than the actual demand. This electricity productivity improvement could be further enhanced through a balanced approach to penalizing inefficiency through appropriate energy pricing structures while encouraging conservation through incentives. The present emphasis on increasing electrical energy generating capacity is based on forecasts that do not properly account for future trends in electricity productivity that have been emerging for over a decade.

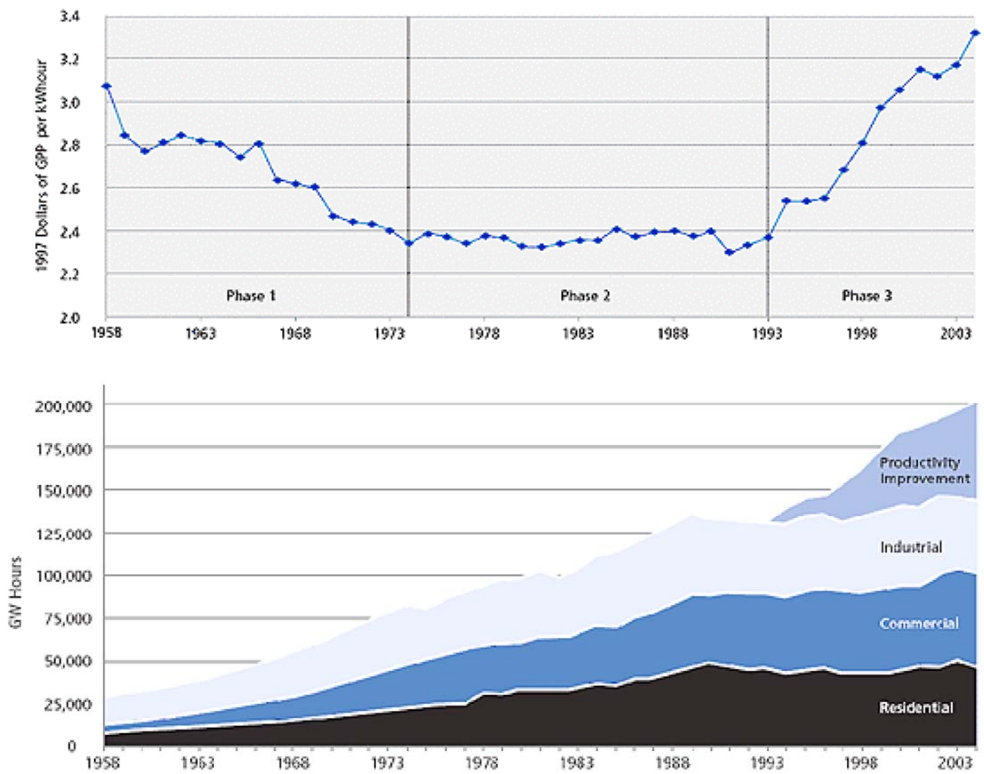

Figure 10. Electricity productivity in Ontario, 1958 – 2003.
[Source: Conservation Bureau of Ontario.
http://www.conservationbureau.on.ca/Page.asp?PageID=122&ContentID=1486&SiteNodeID=166

Synopsis

This cost-benefit analysis of energy conservation measures for multi-unit residential buildings, specifically new condominiums, has revealed a number of interesting relationships among building design, energy modeling, incentives and affordability. These have been summarized as follows:

- When assuring compliance for new buildings, including MURBs, with the energy efficiency requirements of the Ontario Building Code, it is critical that the effective thermal resistance values of building envelope assemblies are correctly applied. Thermal bridging, especially as it occurs across exposed cantilevered balconies without thermal breaks, remains a major source of uncontrolled heat transfer that results in poor energy performance, and possibly premature deterioration of envelope materials and components. Added insulation for walls and roofs, beyond the levels currently required by the Code, are economically justifiable, but these must be detailed to reduce thermal bridging and deliver all of the thermal benefit of the added insulation.
- The selection of glass area and glazing characteristics is critical to the energy performance of buildings. When the glazing area exceeds 50% of the gross exterior wall area, it is technically and economically difficult to achieve energy performance that complies with the requirements of the Toronto Green Development Standard. High performance windows are a cost effective means of improving energy efficiency and thermal comfort.
- Heat recovery from exhaust air leaving the building is a highly cost effective and easily implemented conservation measure. The technology is mature and is well supported by the current mechanical service industry.
- High efficiency boilers and chillers are cost effective investments that do not require special accommodation, simply a change in the equipment specifications. Efficient chillers also contribute to lowering peak electrical energy demand.
- Water conserving fixtures and appliances are cost effective based on energy savings alone (hot water). The reduced cost of potable water makes water conservation an easily implemented energy conservation measure with little or no added initial cost.
- Variable drive pumps represent the most cost effective energy conservation measure in buildings. This is a widely available, off-the-shelf technology that reduces energy consumption without sacrificing reliability or requiring specialized design.
- Lighting controls, especially in areas where illumination is required on a 24-hour basis, such as underground parkades, can cost effectively reduce energy consumption. When coupled to energy efficient lamps, the life cycle costs of artificial lighting can be significantly reduced in buildings.
- From a life cycle perspective, the formula for a green MURB is rather simple: design and build the best performing envelope money can afford; install energy efficient HVAC equipment, plumbing fixtures and water conserving appliances; and deal intelligently with all continuous loads like pumping, lighting and ventilation.

The next cost-benefit analysis of energy conservation measures looks at office buildings. It is important to appreciate that buildings consume energy in relation to their occupancy patterns. Whereas residential buildings are occupied on a continuous basis, office buildings tend to be occupied during regular business hours, 5 days a week, but much more intensely.

Office Buildings

Energy conservation measures for office buildings were selected during an energy performance workshop conducted at the University of Toronto. Results of the energy simulations and costs associated with the measures were later analyzed according to the three economic measures discussed earlier in this report. Before turning to a discussion of those results, it is useful to appreciate the office building market, also referred to as commercial real estate development.

Commercial market activity in Canada should be brisk in 2008 even as the pace of residential building gradually cools. Notwithstanding a number of major new office tower developments currently underway, centred in Toronto and Calgary, significant new space is not expected until 2009.

"Given a high pre-lease ratio, vacancy rates should remain low and rents on the rise," Ms. Warren said in her presentation. "The national downtown office vacancy rate hit a 22-year low of just 4.7 per cent in the final quarter of 2007, with both Calgary and Vancouver below the three per cent mark. Demand for new office space is being supported by strong employment growth, environmental and technical upgrades, and institutional investor interest."

Adrienne Warren, Senior Economist, Scotiabank
Scotiabank Canadian Real Estate Outlook and Trends Forum, February 26, 2008, Toronto ON.

In the early 1990s, investment in Toronto commercial real estate development was more or less stagnant, except for an uninterrupted ripple of high-rise condo towers on the city's waterfront and throughout the downtown core.

These days, however, the city is in the midst of a revival, with three new towers encompassing 3.1 million sq. ft. under construction a few blocks apart in Toronto's CBD. All three new buildings were designed to obtain the silver Leadership in Energy and Environmental Design (LEED) certification standards upon completion in 2009. LEED is the North American standard for the design and construction of environmentally sustainable buildings.

Rents in the new towers range from the high $20s to mid $30s per sq. ft., which their owners hope will increase to a range between the high $30s to $40 per sq. ft. as space fills up, McNair says. [* Sandy McNair, president of InSite Real Estate Information Systems based in Toronto.]*

In the meantime, potential tenants are waiting to see what moves the Bank of Canada will make regarding interest rates, commodity prices, the impact of an uneven U.S. economy and reduced global competitiveness inspired by the rising value of the Canadian dollar — almost at par with the U.S. dollar.

While downtown development was stagnant from the early 1990s, office development in the suburbs was quite healthy. Approximately 13 million sq. ft. of space in small 100,000 to 300,000 sq. ft. office buildings were built over the past seven years in the greater Toronto area, according to McNair.

That, together with the previous suburban office space inventory of 29 million sq. ft., brings the current suburban inventory to 42 million sq. ft. Added to Toronto's existing 60 million sq. ft., the combined inventories come to 102 million sq. ft.
Excerpted from ***Office Towers Sprout*** *by Albert Warson, July 1, 2007.*
http://nreionline.com/property/office/real_estate_office_towers_sprout/

Market research indicates there is pent up demand for offices in the Greater Toronto Area & Hamilton (GTAH) and high levels of office building construction activity are forecast over the next few years. Opportunities to advance green office building practices are ideally positioned as the demand for technically and environmentally advanced buildings is increasing among a commercial sector that is competing internationally to attract and retain knowledge workers.

Baseline Office Building

The model office building used to perform the cost-benefit analysis of energy conservation measures is depicted in Figure 10. It is an 11-storey building with 10 floors of office space and a main floor retail space, for a total of 220,000 ft^2 of conditioned floor area. The single storey of underground parking is unconditioned, but illuminated and ventilated. Glazing accounts for 40% of the gross exterior wall area. The complete description and characteristics of the baseline building are detailed in Appendix B.

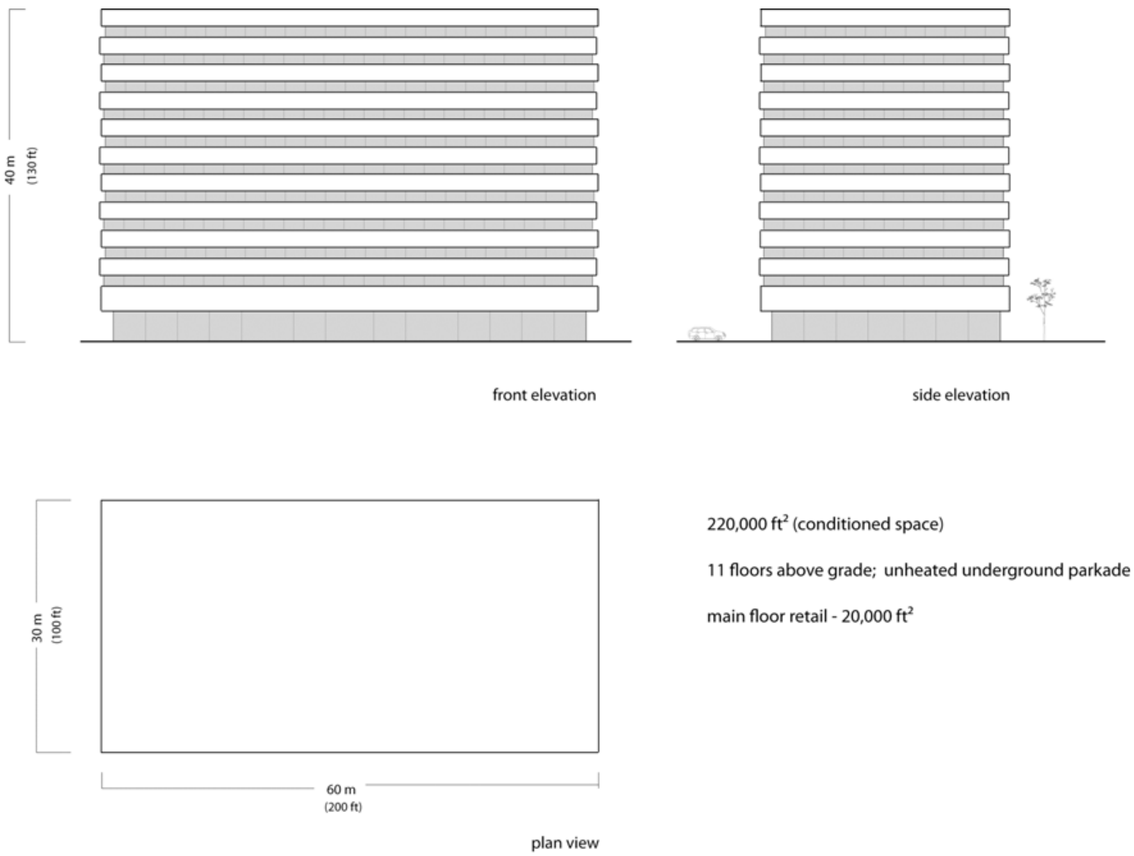

Figure 10. Model office building used for energy simulation and cost-benefit assessment.

It is important to note that two different HVAC systems were modeled for the office building. The first HVAC system is a variable-air-volume (VAV) system that is most commonly used in commercial buildings, and the second is a distributed water source heat pump (WSHP) system. The results of the cost-benefit analysis are presented in Table 10. A legend explaining the entries in the cost-benefit analysis may be found in Figure 9 on Page 48.

Office Building Energy Conservation Cost-Benefit Analysis

The analyses presented in Table 10 are based on the same two interest (discount) rate and energy price escalation rate scenarios used for MURBs. The discussion which follows is divided into two parts: a) the first discusses energy conservation measures when a variable-air-volume (VAV) HVAC system is used; b) the second presents the case where a distributed water source heat pump (WSHP) system is used to condition the building.

Variable-Air-Volume (VAV) System

The baseline VAV office building was estimated to have an annual energy cost of $437,250 and generates 1,304 tonnes of greenhouse gas emissions (CO_2 equivalent). As a baseline building, by definition the payback period and internal rate of return are not applicable. The net present value (NPV) of the energy costs are indicated for the three study periods of 25, 50 and 75 years, according to the two economic scenarios. Looking at the current scenario, the 25-year net present value is $15,033,933 and this rises to $90,521,741 for a 75-year period. By comparison, under the high scenario, the 25-year net present value is $20,884,089, rising to $291,191,541 for a 75-year period. The 25-year net present values represent the energy cost burden to the first generation occupying the baseline building. The 50-year and 75-year net present values reflect possible future burdens for succeeding generations.

Table 10. Office Building – Energy and Economic Assessment of Energy Conservation Measures

This analysis is based on an energy performance workshop conducted by EnerSys Analytics Inc.
Economic measures based on:
ASTM E 1057 Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems
ASTM E 1121 Measuring Payback for Investments in Buildings and Building Systems
ASTM E 917 Measuring Life Cycle Costs of Buildings and Building Systems

Effects of energy conservation measures (ECMs) on equipment downsizing have been applied.

Economic Assessment Parameters

Two interest (discount) rate and energy escalation rate scenarios are considered in this analysis.

Indicates cost allowance for ECM to deliver the corresponding payback period under current scenario.

	Current	***High***
Interest Rate	**5.5%**	**7.0%**
Energy Escalation Rate	**8.0%**	**12.0%**
Study Period (yrs)	**25**	**25**
	50	**50**
	75	**75**

Cost-Benefit Analysis

		Annual	**Current**			**High**		
	Cost	**Savings**	**PB (years)**	**IRR**	**NPV**	**PB (years)**	**IRR**	**NPV**
Baseline VAV	$0	$0	N/A	N/A	**$15,033,933**	N/A	N/A	**$20,884,089**
$403,207 Elec.					**$42,033,390**			**$86,298,231**
$34,043 Nat. Gas					**$90,521,741**			**$291,191,541**
1,304 T of CO2e								
ECM #1a Install occupancy controls in 70% of the building. (with VAV System)								
	$162,798	$23,743	6.3	23.2%	**$14,380,378**	5.8	27.7%	**$19,912,865**
$374,797 Elec.		5.43%			**$39,913,744**			**$81,774,971**
$38,710 Nat. Gas					**$85,769,141**			**$275,542,422**
1,250 T of CO2e								

ECM #2a	Install On/Off daylighting controls for 10% of the building. (with VAV System)								
		$108,439	$1,131	49.9	-1.1%	**$15,103,485**	36.4	2.5%	**$20,938,508**
$401,854	Elec.		0.26%			**$42,033,104**			**$86,183,449**
$34,265	Nat. Gas					**$90,396,035**			**$290,546,778**
1,301	T of CO2e								
ECM #3a	Install daylighting control dimming ballast for 10% of the building. (with VAV System)								
		$205,417	$3,393	37.4	1.6%	**$15,122,689**	28.7	5.4%	**$20,927,448**
$399,148	Elec.		0.78%			**$41,912,634**			**$85,833,986**
$34,709	Nat. Gas					**$90,024,722**			**$289,137,352**
1,296	T of CO2e								
ECM #4a	Power Quality Improvements - Harmonic loss mitigation. The distribution transformers are higher efficiency improving power quality and reducing costs. (with VAV System)								
		$10,216	$9,745	1.0	111.0%	**$14,709,088**	1.0	118.8%	**$20,428,861**
$392,646	Elec.		2.23%			**$41,106,807**			**$84,385,117**
$34,859	Nat. Gas					**$88,514,497**			**$284,711,965**
1,278	T of CO2e								
ECM #5a	Install occupancy sensors covering half the total garage area (20,000 ft2). (with VAV System)								
		$90,000	$13,288	6.2	23.4%	**$14,667,053**	5.8	27.9%	**$20,339,423**
$387,696	Elec.		3.04%			**$40,845,998**			**$83,765,633**
$36,266	Nat. Gas					**$87,860,791**			**$282,432,248**
1,272	T of CO2e								

Energy conservation measures #1a to #5a represent means of conserving energy for lighting, with the exception of ECM #4a, which addresses power quality improvement for the entire facility. In general, occupancy controls serving 70% of the lighting fixtures were found to be cost effective, while daylighting controls for 10% of the illuminated building area (perimeter zones) in office buildings were not found to be cost effective due to the high initial cost of this control technology and the relatively small proportion of lighting energy conserved. By contrast, power quality improvements are highly cost effective and represent a small incremental investment yielding the most impressive payback period and rate of return. Installing occupancy sensors controlling half the light fixtures serving the underground parking area is also cost effective, due largely to the need for illumination on a 24-hour basis.

ECM #6a	Increase wall insulation by R-5 (1" rigid insulation) on opaque walls. (with VAV System)								
		$68,396	$1,524	30.4	3.6%	**$15,049,930**	24.1	7.4%	**$20,879,695**
$402,793	Elec.		0.35%			**$41,955,282**			**$86,065,842**
$32,933	Nat. Gas					**$90,274,631**			**$290,245,012**
1,297	T of CO2e								
ECM #7a	Increase roof insulation by R-10 (2" rigid insulation). (with VAV System)								
		$50,539	$967	33.9	2.6%	**$15,051,224**	26.4	6.4%	**$20,888,441**
$403,114	Elec.		0.22%			**$41,990,970**			**$86,157,917**
$33,169	Nat. Gas					**$90,372,087**			**$290,598,096**
1,299	T of CO2e								

Increasing wall and roof insulation levels beyond the assumed effective thermal resistance values of R-17 (RSI 3.0) and R-20 (RSI 3.5) was found to be not cost effective. It is important to note that the nominal amount of insulation installed to achieve the effective thermal resistance values used in this analysis corresponds to approximately R-25 (RSI 4.4) for walls and R-30 (RSI 5.3) for roofs. Thermal bridging reduces the installed insulation to significantly lower effective thermal resistance values over the entire building envelope assembly.

ECM #8a	Improve window U-value by 30%. (with VAV System)								
		$119,497	$8,514	12.0	13.4%	**$14,860,694**	10.7	17.6%	**$20,596,937**
$402,563	Elec.		1.95%			**$41,334,425**			**$84,737,355**
$26,173	Nat. Gas					**$88,878,626**			**$285,641,044**
1,263	T of CO2e								
ECM #9a	Sensitivity to test change in shading coefficient on four distinct orientations. On North: increased solar gain; on East, South, West: decreased solar gain. (with VAV System)								
		$80,500	$2,336	25.0	5.5%	**$15,034,115**	20.4	9.4%	**$20,853,016**
$400,442	Elec.		0.53%			**$41,889,327**			**$85,917,685**
$34,472	Nat. Gas					**$90,118,630**			**$289,716,356**
1,298	T of CO2e								
ECM #10a	Window U-Value and Shading Coefficient Improvement (U-value: 45% improvement, shading coefficient: 40% improvement.) Costing based on $55 per ft2 option in EEM costing spreadsheet. (with VAV System)								
		$613,625	$32,578	15.5	10.5%	**$14,527,432**	13.4	14.6%	**$19,941,712**
$384,084	Elec.		7.45%			**$39,515,251**			**$80,482,071**
$20,588	Nat. Gas					**$84,390,901**			**$270,109,482**
1,185	T of CO2e								
ECM #11a	Window Improvements and 60% Glazing. ECM 10a, with the addition of 50% more glass to result in 60% overall glazing. (with VAV System)								
		$636,430	$17,355	26.2	5.0%	**$15,073,648**	21.2	8.9%	**$20,691,603**
$391,736	Elec.		3.97%			**$41,001,462**			**$83,509,376**
$28,159	Nat. Gas					**$87,565,250**			**$280,270,214**
1,243	T of CO2e								
ECM #12a	2 ft Overhangs around building at approximately $700,000. (with VAV System)								
		$689,475	$5,476	58.3	0.0%	**$15,535,128**	41.4	0.9%	**$21,312,017**
$397,565	Elec.		1.25%			**$42,196,450**			**$85,906,931**
$34,209	Nat. Gas					**$90,077,547**			**$288,234,212**
1,289	T of CO2e								
ECM #13a	2 ft Overhangs around building at about $150,000 (same as ECM 12-a, but with lower capital cost to see where the cost needs to be to get it to a 20-year payback). (with VAV System)								
		$139,475	$5,476	19.8	7.8%	**$14,985,128**	16.6	11.8%	**$20,762,017**
$397,565	Elec.		1.25%			**$41,646,450**			**$85,356,931**
$34,209	Nat. Gas					**$89,527,547**			**$287,684,212**
1,289	T of CO2e								

ECMs #8a to #13a deal with windows and shading devices. Office buildings normally expend more energy on cooling than heating due to the high occupancy (# of people per unit of floor area) and numerous heat sources (lights, computers, copiers, etc.). A 30% improvement in window U-value was found to be reasonably cost effective. ECM #9a considers a sensitivity analysis of varying the shading coefficients of the glazing. Assuming a 25-year payback under the current energy price escalation scenario, an additional $80,500 could be invested toward this measure, however, it should noted that in reality this represents a no-cost measure. ECM #10a indicates that moving to a high performance window system carries a higher initial cost than a modest window performance upgrade, but yields comparable paybacks and rates of return and a significantly better life cycle cost. For ECM #11a, the impact of increasing the high performance window area by 50% was analyzed. It was found to yield long payback periods, low rates of return, and a 25-year life cycle cost comparable to the baseline building. Large glazing areas significantly reduce the cost effectiveness of office buildings. ECMs #12a an #13a examine the effects of overhangs, and conclude their initial cost is too high for the benefits obtained. Techniques such as deeply recessed windows and interior shading devices, while not as effective as properly designed external shading devices, are currently more cost effective.

ECM #14a	Lower cooling setpoint by 2°F. This is a controls issue, no capital cost. Not really eligible for CBIP/LEED but does demonstrate the relative influence of temperature setpoint changes. (with VAV System)								
		$0	$21,022	0.0	N/A	**$14,311,136**	0.0	N/A	**$19,880,029**
$386,775	Elec.		4.81%			**$40,012,519**			**$82,149,206**
$29,453	Nat. Gas					**$86,169,659**			**$277,191,704**
1,236	T of CO2e								
ECM #15a	Replace on/off burners with fully modulating ones. Capital costs were $4,400 for 3 boilers. (with VAV System)								
		$4,400	$3,873	1.1	103.1%	**$14,905,168**	1.1	110.6%	**$20,703,505**
$403,207	Elec.		0.89%			**$41,665,474**			**$85,538,233**
$30,170	Nat. Gas					**$89,724,333**			**$288,616,673**
1,285	T of CO2e								
ECM #16a	Replace on/off burners with condensing boilers. Capital costs were $19,800 for 3 boilers. (with VAV System)								
		$19,800	$8,186	2.3	52.6%	**$14,772,275**	2.2	58.3%	**$20,512,906**
$403,207	Elec.		1.87%			**$41,266,259**			**$84,702,394**
$25,857	Nat. Gas					**$88,846,833**			**$285,759,783**
1,264	T of CO2e								
ECM #17a	Install a chiller with an 8.33% better COP. (with VAV System)								
		$44,000	$3,033	12.4	13.1%	**$14,973,650**	10.9	17.3%	**$20,783,225**
$400,174	Elec.		0.69%			**$41,785,824**			**$85,743,621**
$34,043	Nat. Gas					**$89,937,834**			**$289,215,681**
1,296	T of CO2e								
ECM #18a	Variable speed drives on fans. 324 HP @ 200/HP for a total cost of $62,400. (with VAV System)								
		$62,400	$9,938	5.8	24.7%	**$14,754,636**	5.4	29.4%	**$20,471,826**
$392,644	Elec.		2.27%			**$41,140,438**			**$84,399,209**
$34,668	Nat. Gas					**$88,526,725**			**$284,635,619**
1,277	T of CO2e								
ECM #19a	Variable speed drives on pumps. Heating and cooling pumps at 326 HP @ $200 /HP. (with VAV System)								
		$63,033	$40,727	1.5	77.8%	**$13,696,653**	1.5	84.4%	**$19,001,904**
$355,924	Elec.		9.31%			**$38,181,285**			**$78,323,144**
$40,599	Nat. Gas					**$82,153,261**			**$264,131,972**
1,200	T of CO2e								

ECMs #14a to #19a deal with improved HVAC system operation and equipment efficiency. It is generally accepted that an improved building envelope that is well insulated, airtight and fitted with high performance windows permits the cooling set point to be relaxed by 2 ^{O}F (approximately 1 ^{O}C). The annual savings are significant and would certainly cover the annual cost of an investment in a sophisticated building energy management system. Replacing simple on/off boilers with modulating or condensing boiler technology is highly cost effective due to the low incremental cost. Improving chiller performance, as in ECM #17a, is also cost effective, but does not yield comparable benefits to boiler technology improvements. Variable speed drives on VAV system fans represent a highly cost effective measure, but variable speed drives on pumps provide an exceptional payback period, return on investment and impressive life cycle savings.

ECM #20a	Demand Control Ventilation - 80% coverage, no fan change, 0.4 cfm per ft2 minimum. $1,500 per sensor. 20 Sensors. (with VAV System)								
		$28,878	$7,454	3.7	35.8%	**$14,806,521**	3.5	40.8%	**$20,556,946**
$397,293	Elec.		1.70%			**$41,345,706**			**$84,855,944**
$32,503	Nat. Gas					**$89,007,454**			**$286,256,344**
1,277	T of CO2e								
ECM #21a	Shading South and West. 2 ft overhangs south windows (85' average window length) for 11 floors. In addition, 2 ft vertical fins on west windows (south side of window only). These windows are 10' length, 6' high with 7 windows per floor. (with VAV System)								
		$409,125	$5,476	42.9	0.3%	**$15,254,778**	32.1	4.0%	**$21,031,667**
$397,565	Elec.		1.25%			**$41,916,100**			**$85,626,581**
$34,209	Nat. Gas					**$89,797,197**			**$287,953,862**
1,289	T of CO2e								
ECM #22a	Heat Recovery office floors. Enthalpy heat recovery on office make-up air unit. Costs based on $10 per cfm. (with VAV System)								
		$253,959	($6,108)	N/A	N/A	**$15,497,903**	N/A	N/A!	**$21,429,780**
$410,201	Elec.		-1.40%			**$42,874,519**			**$87,757,701**
$33,157	Nat. Gas					**$92,040,210**			**$295,513,191**
1,319	T of CO2e								

Several energy conservation measures were examined in ECMs #20a, #21a and #22a. Demand controlled ventilation relies on carbon dioxide sensors to monitor the air quality and adjust the ventilation rate accordingly. Savings accrue because areas with no or low ventilation demand (unoccupied or very low occupancy zones) are only provided with a minimum flow rate of outside air. Demand controlled ventilation was found to be very cost effective and represents a relatively low additional cost.

Properly designed and placed shading devices were re-examined in ECM #21a and while it was possible to reduce their initial cost through selective placement, it was not possible to convert them into a cost effective measure based on payback period, rate of return and life cycle cost over a 25-year period. Eventually (on average after 50 years) shading devices become cost effective but this assumes they are durable and require no maintenance during this period. Clearly, the high initial cost of external shading devices is a barrier to cost effectiveness that represents an innovation opportunity.

ECM #22a looks at the installation of heat recovery on office floors only. VAV systems are not well suited to heat recovery technology because they operate as dilution systems where the fresh air is introduced into the recirculating conditioned air of the building, and the exhaust air is extracted from a small portion of this recirculating air. As a result, heat recovery efficiency is very low and less energy is recovered than is required to operate the heat recovery device, resulting in a net energy deficit. Put simply, heat recovery from conventional VAV systems is not applicable.

Finally, the cost benefit analysis was extended to various combinations of energy conservation measures. Combo 1 was selected based on the most cost effective energy conservation measures. Combo 2 is the same as Combo 1, but with 50% higher glazing area (glazing area goes from 40% of gross exterior wall area to 60%). Combo 3 is similar to Combo 2, but without the high performance windows. Finally, Combo 4 includes the measures in Combo 3 except the office occupancy sensors and garage occupancy sensors for lighting control are removed.

VAV Combo 1	Measures initially selected based on cost effectiveness. ECMs #1a + #4a + #5a + #10a + #15a + #18a + #19a								
		$1,000,218	$131,593	6.9	21.5%	**$11,509,599**	6.4	26.0%	**$15,599,115**
$274,596	Elec.		30.10%			**$30,383,408**			**$61,326,481**
$31,061	Nat. Gas					**$64,278,900**			**$204,555,925**
927	T of CO_2e								
VAV Combo 2	Same as Combo 1, but with higher relative glazing amount. ECMs #1a + #4a + #5a + #11a + #15a + #18a + #19a								
		$1,023,023	$117,540	7.8	19.4%	**$12,015,588**	7.2	23.8%	**$16,293,125**
$282,248	Elec.		26.88%			**$31,757,146**			**$64,122,869**
$37,462	Nat. Gas					**$67,211,030**			**$213,937,483**
979	T of CO_2e								
VAV Combo 3	Includes most measures from Combo 2 but removes the window improvement. ECMs #1a + #4a + #5a + #15a + #18a + #19a								
		$386,593	$101,055	3.6	36.1%	**$11,945,960**	3.5	41.2%	**$16,444,057**
$293,719	Elec.		23.11%			**$32,705,439**			**$66,740,015**
$42,476	Nat. Gas					**$69,987,409**			**$224,279,424**
1,036	T of CO_2e								
VAV Combo 4	Includes most measures from Combo 3, but removes the office occupancy sensors. ECMs #4a + #15a + #18a + #19a								
		$137,437	$65,442	2.0	59.4%	**$12,921,283**	2.0	65.3%	**$17,895,862**
$334,799	Elec.		14.97%			**$35,879,806**			**$73,519,650**
$37,009	Nat. Gas					**$77,111,039**			**$247,747,144**
1,122	T of CO_2e								

The relationship between the combinations of energy conservation measures offers insights on the effective integration of building systems. Starting with Combo 1, the additional construction cost of $1,000,218 provides a 30.1% reduction in annual energy demand and savings of $131,593 per year. The payback period is 6.9 years, the rate of return 21.5%, and the life cycle savings are $3,524,334 under the current energy price escalation rate scenario for a 25-year period. For the high scenario, these measures become 6.4 years, 26.0% and $5,284,974 respectively. Combo 1 represents the best life cycle cost effectiveness, whereas Combo 4, which has the lowest additional cost and annual savings, yields the lowest payback periods and highest rates of return. From a developer perspective, the lower capital cost measures may appear attractive, but from a consumer perspective, Combo 1 only takes 4.9 years longer to payback than Combo 4, but yields nearly $2.3 million more in life cycle savings over 25 years. It is noteworthy that only Combos 1 and 2 comply with the energy efficiency requirements of the Toronto Green Development Standard.

Water Source Heat Pump (WSHP) System

The baseline WSHP office building was estimated to have an annual energy cost of $508,374 (versus $437,250 for the VAV system) and generates 1,508 tonnes (versus 1,304 tonnes for the VAV case) of greenhouse gas emissions (CO_2 equivalent). As a baseline building, by definition the payback period and internal rate of return are not applicable. The net present values (NPV) of the energy costs are indicated for the three study periods of 25, 50 and 75 years, according to the two economic scenarios. Looking at the current scenario, the 25-year net present value is $17,479,385 (versus $15,033,933 for the VAV case) and this rises to $105,246,197 (versus $90,521,741 for the VAV case) for a 75-year period. By comparison, under the high scenario, the 25-year net present value is $24,281,138 (vs $20,884,089 for VAV), rising to $338,557,367 (vs $291,191,541 for VAV) for a 75-year period. Water source heat pump systems incur higher operating costs, largely associated with the large number of compressors and pumps in operation throughout the system. But they offer the advantage of being more flexible than VAV systems in accommodating churn rates in offices and offering zone control to changing tenant occupancy patterns.

Baseline WSHP		$0	$0	N/A	N/A	**$17,479,385**	N/A	N/A	**$24,281,138**
$472,659	Elec.					**$48,870,629**			**$100,335,682**
$35,715	Nat. Gas					**$105,246,197**			**$338,557,367**
1,508	T of CO2e								
ECM #1b	Install occupancy controls in 70% of the building. (with WSHP System)								
		$157,831	$31,855	4.6	29.6%	**$16,541,948**	4.4	34.4%	**$22,917,500**
$439,509	Elec.		6.27%			**$45,966,199**			**$94,206,423**
$37,010	Nat. Gas					**$98,809,242**			**$317,501,003**
1,220	T of CO2e								
ECM #2b	Install On/Off daylighting controls for 10% of the building. (with WSHP System)								
		$108,202	$1,518	41.6	0.6%	**$17,535,393**	31.3	4.3%	**$24,316,837**
$471,080	Elec.		0.30%			**$48,832,904**			**$100,144,283**
$35,776	Nat. Gas					**$105,040,135**			**$337,654,639**
1,300	T of CO2e								
ECM #3b	Install daylighting control dimming ballast for 10% of building. (with WSHP System)								
		$204,707	$4,551	30.5	3.6%	**$17,527,615**	24.1	7.4%	**$24,268,479**
$467,923	Elec.		0.90%			**$48,637,843**			**$99,642,177**
$35,900	Nat. Gas					**$104,508,733**			**$335,731,284**
1,292	T of CO2e								
ECM #4b	Power Quality Improvements – Harmonic loss mitigation. The distribution transformers are higher efficiency improving power quality and reducing costs. (with WSHP System)								
		$9,521	$12,607	0.7	151.0%	**$17,055,440**	0.7	160.3%	**$23,688,519**
$459,906	Elec.		2.48%			**$47,668,223**			**$97,857,012**
$35,861	Nat. Gas					**$102,645,752**			**$330,171,114**
1,269	T of CO2e								
ECM #5b	Install occupancy sensors covering half the garage area (20,000 ft2). (with WSHP System)								
		$90,000	$17,156	4.9	28.3%	**$16,979,511**	4.6	33.1%	**$23,551,727**
$454,886	Elec.		3.37%			**$47,311,401**			**$97,039,673**
$36,332	Nat. Gas					**$101,784,474**			**$327,222,136**
1,258	T of CO2e								

Cost effectiveness relationships for lighting and power quality measures are similar for WSHP and VAV systems. Occupancy controls for lighting, power quality improvements and occupancy sensors for underground parking area lighting represent cost effective measures.

ECM #6b	Increase wall insulation by R-5 (1" rigid insulation) on opaque walls. (with WSHP System)								
		$67,864	$1,432	31.6	3.2%	**$17,498,012**	24.9	7.1%	**$24,280,607**
$471,480	Elec.		0.28%			**$48,800,833**			**$100,120,918**
$35,462	Nat. Gas					**$105,017,601**			**$337,671,574**
1,299	T of CO2e								
ECM #7b	Increase roof insulation by R-10 (2" rigid insulation). (with WSHP System)								
		$45,463	$366	57.8	0.0%	**$17,512,263**	41.1	1.0%	**$24,309,120**
$472,943	Elec.		0.07%			**$48,880,908**			**$100,308,909**
$35,065	Nat. Gas					**$105,215,889**			**$338,359,088**
1,301	T of CO2e								

Increased levels of wall and roof insulation beyond the levels provided in the baseline building are less cost effective when WSHP systems are employed because savings associated with equipment downsizing are lower due to the incremental sizes of heat pump units. Unlike VAV systems where central heating or cooling equipment can be marginally downsized, WSHP units are manufactured in discrete sizes where the next lower capacity unit may be insufficient to meet the reduced loads.

ECM #8b	Improve window U-value by 30%. (with WSHP System)								
		$121,477	$4,340	21.3	7.1%	**$17,451,640**	17.8	11.0%	**$24,195,327**
$469,184	Elec.		0.85%			**$48,574,896**			**$99,600,591**
$34,850	Nat. Gas					**$104,469,185**			**$335,788,572**
1,290	T of CO2e								
ECM #9b	Sensitivity to test change in shading coefficient on four distinct orientations. On North: increased solar gain; on East, South, West: decreased solar gain (with WSHP System)								
		$152,000	$4,431	25.0	5.5%	**$17,479,034**	20.3	9.4%	**$24,221,503**
$468,066	Elec.		0.87%			**$48,596,672**			**$99,613,154**
$35,877	Nat. Gas					**$104,480,869**			**$335,758,492**
1,292	T of CO2e								
ECM #10b	Window U-Value and Shading Coefficient Improvement (U-value: 45% improvement, shading coefficient: 40% improvement.) Costing based on $55 per ft2 option in EEM costing spreadsheet. (with WSHP System)								
		$636,470	$31,096	16.6	9.7%	**$17,046,683**	14.2	13.8%	**$23,432,390**
$442,174	Elec.		6.12%			**$46,517,802**			**$94,834,863**
$35,104	Nat. Gas					**$99,445,013**			**$318,485,107**
1,212	T of CO2e								
ECM #11b	Window Improvements and 60% Glazing. ECM 10b, with the addition of 50% more glass to result in 60% overall glazing. (with WSHP System)								
		$663,775	$13,234	32.9	2.9%	**$17,688,136**	25.7	6.7%	**$24,312,826**
$458,692	Elec.		2.60%			**$48,262,203**			**$98,387,517**
$36,448	Nat. Gas					**$103,170,201**			**$330,407,811**
1,260	T of CO2e								
ECM #12b	2 ft Overhangs around building at approximately $700,000. (with WSHP System)								
		$669,109	$5,934	54.8	-2.0%	**$17,944,465**	39.4	1.6%	**$24,666,825**
$466,553	Elec.		1.17%			**$48,969,295**			**$99,833,622**
$35,887	Nat. Gas					**$104,686,819**			**$335,274,662**
1,287	T of CO2e								
ECM #13b	2 ft Overhangs around building at about $150,000 (same as ECM 12-b, but with lower capital cost to see where the cost needs to be to get it to a 20-year payback). (with WSHP System)								
		$149,109	$5,934	19.6	8.0%	**$17,424,465**	16.5	12.0%	**$24,146,825**
$466,553	Elec.		1.17%			**$48,449,295**			**$99,313,622**
$35,887	Nat. Gas					**$104,166,819**			**$334,754,662**
1,287	T of CO2e								

The influence of window performance and shading devices on the cost effectiveness of these measures is comparable for WSHP and VAV systems. Variations in ECMs #8b to #13b are primarily related to the higher value of energy savings due to the WSHP system being more dependent on electrical energy than VAV systems.

ECM #14b	Lower cooling setpoint by 2°F This is a controls issue, no capital cost. Not really eligible for CBIP/LEED but does demonstrate the relative influence of temperature setpoint changes. (with WSHP System)								
		$0	$20,944	0.0	N/A	**$16,740,495**	0.0	N/A	**$23,262,030**
$450,443	Elec.		4.12%			**$46,838,482**			**$96,183,277**
$36,987	Nat. Gas					**$100,891,489**			**$324,590,701**
1,249	T of CO2e								
ECM #15b	Replace on/off burners with fully modulating ones. Capital costs were $4,400 for 3 boilers. (with WSHP System)								
		$4,400	$3,112	1.4	84.4%	**$17,376,785**	1.3	91.2%	**$24,136,902**
$472,659	Elec.		0.61%			**$48,575,869**			**$99,725,880**
$32,603	Nat. Gas					**$104,606,335**			**$336,489,295**
1,288	T of CO2e								
ECM #16b	Replace on/off burners with condensing boilers. Capital costs were $19,800 for 3 boilers. (with WSHP System)								
		$19,800	$8,313	2.3	53.3%	**$17,213,359**	2.2	59.0%	**$23,903,890**
$472,659	Elec.		1.64%			**$48,091,290**			**$98,714,780**
$27,402	Nat. Gas					**$103,544,997**			**$333,041,031**
1,262	T of CO2e								
ECM #17b	Install a heat pump with an 8.33% better COP. (with WSHP System)								
		$43,542	$6,946	5.8	24.8%	**$17,284,103**	5.4	29.4%	**$23,992,923**
$465,713	Elec.		1.37%			**$48,246,443**			**$99,008,321**
$35,715	Nat. Gas					**$103,851,742**			**$333,975,142**
1,285	T of CO2e								
ECM #18b	**No corresponding ECM for WSHP systems.**								
ECM #19b	Variable speed drives on pumps. Heating and cooling pumps at 326 HP @ $200 /HP. (with WSHP System)								
		$32,823	$32,102	1.0	113.6%	**$16,408,447**	1.0	121.5%	**$22,780,694**
$439,895	Elec.		6.31%			**$45,817,447**			**$94,032,666**
$36,377	Nat. Gas					**$98,633,099**			**$317,211,503**
1,209	T of CO2e								

In general, investments in improved central HVAC equipment efficiency are slightly less cost effective for WSHP systems versus VAV systems. This is due to the higher consumption of electrical energy for the operation of WSHP systems.

ECM #20b	Demand Ventilation Control – 80% coverage, no fan change, 0.4 cfm per ft2 minimum. $1,500 per sensor. 20 Sensors. (with WSHP System)								
		$30,000	$12,865	2.2	54.3%	**$17,067,048**	2.2	60.0%	**$23,696,676**
$472,000	Elec.		2.53%			**$47,663,901**			**$97,826,570**
$23,509	Nat. Gas					**$102,612,819**			**$330,019,775**
1,241	T of CO2e								
ECM #21b	Shading South and West. 2 ft overhangs south windows (85' average window length) for 11 floors. In addition, 2 ft vertical fins on west windows (south side of window only). These windows are 10' length, 6' high with 7 windows per floor. (with WSHP System)								
		$418,759	$5,934	41.3	0.7%	**$17,694,115**	31.2	4.4%	**$24,416,475**
$466,553	Elec.		1.17%			**$48,718,945**			**$99,583,272**
$35,887	Nat. Gas					**$104,436,469**			**$335,024,312**
1,287	T of CO2e								
ECM #22b	Heat Recovery office floors. Enthalpy heat recovery on office make-up air unit. Costs based on $10 per cfm. (with WSHP System)								
		$238,216	$40,674	5.4	26.1%	**$16,319,110**	5.1	30.7%	**$22,576,668**
$453,728	Elec.		8.00%			**$45,198,803**			**$92,546,238**
$13,972	Nat. Gas					**$97,063,873**			**$311,708,276**
1,143	T of CO2e								

Demand controlled ventilation is more cost effective for WSHP systems versus VAV systems because the reduction in energy costs is higher due to the increased reliance on electrical energy by WSHP systems. Selective shading devices remain difficult to justify based on cost effectiveness measures, however, heat recovery becomes highly cost effective for WSHP systems. Ventilation systems are configured differently for WSHP systems than VAV systems and all of the exhaust air heat can be passed through the heat recovery equipment.

WSHP COMBO 1	Measures initially selected based on cost effectiveness. ECMs #1b + #4b + #5b + #10b + #15b + #18b + #19b								
		$1,170,859	$161,280	6.6	22.2%	**$13,104,966**	6.1	26.7%	**$17,748,885**
$332,497	Elec.		31.72%			**$34,537,440**			**$69,675,372**
$14,597	Nat. Gas					**$73,028,042**			**$232,322,001**
795	T of CO2e								
WSHP COMBO 2	Same as Combo 1, but with higher relative glazing amount. ECMs #1b + #4b + #5b + #11b + #15b + #18b + #19b								
		$1,198,175	$143,922	7.5	20.1%	**$13,729,100**	6.9	24.5%	**$18,605,260**
$348,621	Elec.		28.31%			**$36,233,402**			**$73,128,565**
$15,831	Nat. Gas					**$76,648,900**			**$243,909,072**
841	T of CO2e								
WSHP COMBO 3	Includes most measures from Combo 2 but removes the window improvement. ECMs #1b + #4b + #5b + #15b + #18b + #19b								
		$528,568	$132,136	3.8	34.9%	**$13,464,731**	3.6	39.9%	**$18,498,580**
$361,077	Elec.		25.99%			**$36,696,798**			**$74,785,112**
$15,161	Nat. Gas					**$78,419,292**			**$251,088,483**
884	T of CO2e								
WSHP COMBO 4	Includes most measures from Combo 3, but removes the office occupancy sensors. ECMs #4b + #15b + #18b + #19b								
		$443,412	$118,304	3.6	36.7%	**$13,855,159**	3.4	41.8%	**$19,074,073**
$375,355	Elec.		23.27%			**$37,941,329**			**$77,429,921**
$14,715	Nat. Gas					**$81,197,707**			**$260,214,903**
922	T of CO2e								

It is important to note that due to the higher reliance of WSHP systems on electrical energy than VAV systems, all of the Combos 1 through 4 practically comply with the energy efficiency requirements of the TGDS. Again, Combo 1 represents the most cost effective combination of energy conservation measures from a life cycle perspective, as well as a payback perspective.

Table 11 summarizes statistics from the cost-benefit analysis of the office building model. It presents the results for the integrated combinations of energy conservation measures only.

Table 11. Office Building Statistics

Building Areas	ft^2	m^2	***Building Envelope***	ft^2	m^2
Gross Floor Area	220,000	20,449	Roof Area	20,900	1943
Main Floor Retail	20,000	1,859	Gross Wall Area	77,930	7244
			Opaque Wall Area	46,675	4338
			Window Area	31,255	2905
			Percent Glazing	40%	40%

Energy & Conservation Measure Data

	Annual Energy Intensity		Annual Energy Costs		Cost Premium	
	BTU/ft^2	$kWhe/m^2$	$\$/ft^2$	$\$/m^2$	$\$/ft^2$	$\$/m^2$
Baseline VAV	71,200	225	$1.99	$21.39	$0.00	$0.00
VAV Combo 1	51,100	161	$1.39	$14.95	$4.55	$48.91
VAV Combo 2	54,800	173	$1.45	$15.64	$4.65	$50.03
VAV Combo 3	58,600	185	$1.53	$16.45	$1.76	$18.91
VAV Combo 4	62,200	196	$1.69	$18.19	$0.62	$6.72
Baseline WSHP	82,600	260	$2.31	$24.87	$0.00	$0.00
WSHP Combo 1	52,800	167	$1.58	$16.98	$5.32	$57.26
WSHP Combo 2	55,500	175	$1.66	$17.83	$5.45	$58.59
WSHP Combo 3	57,600	182	$1.71	$18.41	$2.40	$25.85
WSHP Combo 4	59,500	188	$1.77	$19.09	$2.02	$21.68

	GHG Emissions			Peak Electricity Demand Reductions (kW)		Avoided Costs
	Tonnes	Reduction	%	Max	%	@ $1,500 / kW
Baseline VAV	1,304	0	0.0%	0.0	0.0%	$0
VAV Combo 1	927	377	28.9%	223.0	23.3%	$334,500
VAV Combo 2	979	325	24.9%	200.0	20.9%	$300,000
VAV Combo 3	1,036	268	20.5%	156.0	16.3%	$234,000
VAV Combo 4	1,122	182	14.0%	70.0	7.3%	$105,000
Baseline VAV peak demands - Heating N/A, Cooling 537.4 kW (July), Max 958 kW (July)						
Baseline WSHP	1,508	0	0.0%	0.00	0.0%	$0
WSHP Combo 1	795	714	47.3%	267.00	26.5%	$400,500
WSHP Combo 2	841	667	44.2%	230.00	22.8%	$345,000
WSHP Combo 3	884	624	41.4%	209.00	20.8%	$313,500
WSHP Combo 4	922	586	38.9%	179.00	17.8%	$268,500

Baseline WSHP peak demands - Heating 389.8 kW (Oct), Cooling 587.4 kW (July), Max 1,007 kW (July). ***NOTE****: Max peak represents both cooling and al other electrical loads.*

VAV Systems

The annual energy intensities of VAV Combos 1 to 4 are 28.4%, 23.1%, 17.8% and 12.9% lower, respectively, than the baseline VAV building. The annual energy costs are correspondingly lower on a unit area basis, adjusting for HVAC system efficiency. The cost premiums associated with the energy conservation measures for Combos 1 to 4 range from $4.55 per ft^2 to $0.62 per ft^2 respectively. Annual energy savings for VAV Combo 1 are $0.60/$ft^2$ and for VAV Combo 2 $0.54/$ft^2$.

Based on life cycle costing, the energy savings support a substantially higher construction budget for VAV Combo 1, in the range of \$16.02 per ft^2 under the current energy price escalation rate scenario and \$24.02 per ft^2 under the high scenario. VAV Combo 2 can economically support a cost premium of \$13.71 per ft^2 under the current energy price escalation scenario, and \$20.87 per ft^2 under the high scenario. Looking at VAV Combo 1, and following the same argument advanced for MURBs, if the criterion for cost effectiveness was the lowest 25-year life cycle cost, then the energy savings for a cost premium of \$4.55 justify an additional investment of \$16.02 in durable, high performance envelopes, HVAC, lighting and control systems. This would in turn lead to lower life cycle costs which would justify further expenditures, however, each iteration would produce diminishing benefits. Assuming the building industry is not able and/or willing to optimize energy conservation investments in buildings, simply using the 25-year life cycle cost criterion would greatly advance the green development agenda.

Greenhouse gas emissions are 28.9% lower for VAV Combo 1 and 24.9% lower for VAV Combo 2 compared to the baseline building. The avoided costs associated with peak electrical energy demand reductions are significant for VAV Combos 1 and 2. Based on a unit cost of \$1,500 per kilowatt for new electrical energy generating capacity, VAV Combo 1 avoids a cost \$334,500 whereas VAV Combo 2 avoids \$300,000. Compared to MURBs, office buildings have higher peak electrical demands per unit of floor area primarily due to their occupancy, lighting intensity and plug loads.

WSHP Systems

The cost effectiveness relationships for WSHP systems are similar to those for VAV systems. The one exception is heat recovery from exhaust air, which is highly cost effective for WSHP system. [**Note:** The heat recovery measure was not included in the WSHP combinations in order to provide a direct comparison with VAV systems.]

In conventional buildings that are not energy efficient, such as the baseline building model used in this study, WSHP systems tend to consume more energy and generate higher levels of greenhouse gas emissions than VAV systems because they are more electricity intensive. Even after energy efficiency measures are taken in the building, the annual energy costs remain slightly higher than for VAV systems. The noticeable difference, however, is that the greenhouse gas reductions are greater for WSHP systems than VAV systems. Electricity consumed in Ontario generates significantly higher emissions than natural gas due to coal-fired generation and imports. As a result, the reductions in greenhouse gases for an electricity intensive WSHP system are greater because the primary source of energy savings is in the form of electrical energy. The same relationship extends to peak electrical energy demand reductions and avoided costs. The baseline WSHP building has a higher peak demand than the VAV building, but after applying the combinations of energy conservation measures, the reduced peak demands are practically the same for both buildings. This suggests that a commonly held view regarding the importance of building envelope efficiency may be valid – high performance envelopes tend to neutralize the energy demand and cost differences between HVAC systems and fuel types.

Synoposis for Energy Conservation Measures in Office Buildings

The energy intensities of the office building model are similar to MURBs, but the difference in occupancy and operating schedule is evident in the higher peak electrical energy demand in office buildings. Office buildings are used more intensely over shorter periods of time (typically 5 days a week during daytime hours), whereas multi-unit residential buildings are used less intensely over longer periods of time (7 days a week, 24 hours a day). These differences aside, there are many common elements to cost effective energy conservation measures applicable to both building typologies.

- There is a direct correlation between glazing area and energy efficiency. Reducing the percentage of the exterior wall area that is glazed is a first step in saving energy. Glazing areas in excess of 50% of the gross exterior wall area are extremely difficult to render energy efficient. The selection of high performance glazing is a cost effective energy conservation measure and it is important to examine different glazing solar heat gain coefficients for the different solar orientations of the building façade.
- Occupancy controls for lighting, and daylighting controls in perimeter areas can cost effectively reduce energy consumption. Occupancy controls in underground parking areas can also reduce energy consumption cost effectively.
- Demand controlled ventilation saves both fan energy and the energy needed to temper ventilation air in office buildings. The cost of carbon dioxide sensors, used to monitor indoor air quality, continues to fall as new technologies are innovated.
- Heat recovery was only feasible for WSHP systems because the ventilation system can be coupled to heat recovery equipment, unlike the case for VAV systems. Heat recovery is a cost effective measure that reduces energy consumption and peak electrical energy demand.
- Water conservation, while always desirable for every form of green development, is not as critical in office buildings due to relatively low consumption of water. Regardless, there is no significant cost premium for water efficient fixtures and appliances.
- High efficiency equipment (fans, pumps, boilers, chillers, etc.) represents cost effective investments and it is expected that with evolving minimum standards for energy efficiency in North America, the selection of high efficiency equipment will become the norm.
- Building automation systems are critical to office buildings in order to respond to changing occupancy conditions. Without them, conditioning in unoccupied zones cannot be turned down, while serving occupants in zones with different schedules. Due to the security requirements in most offices and the installation of computers and telecommunications systems, the marginal costs of building automation systems is decreasing rapidly. This study did not consider building automation systems explicitly, but automated control was assumed in the energy simulation models.
- The energy performance and cost-benefit analyses for offices demonstrate that energy savings afford generous margins for additional investments in durable and efficient building systems. The cost effective improvements address the demand for high quality technical and environmental performance being called for by today's prospective office tenants.

Retail Buildings

The Greater Toronto Area & Hamilton is home to a large number and diverse types of retail buildings, ranging from corner convenience stores to expansive, enclosed malls. In this study, the strip mall or retail plaza, was selected for assessment due to the large number of recent and proposed future developments that have adopted this ubiquitous form. The most recent trend in this type of retail development is known as SmartCentres, and they report the following statistics.

Number of customers in Canada within a 50 mile radius of at least one SmartCentre.
• *Approximately 30 Million (almost the whole country)*

Number of Canadians employed by the tenants of SmartCentres.
• *Over 80,000 and growing*

The number of days you can find a parking spot at a SmartCentre
• *365 a year (that's all of them)*

Number of New Retail Jobs Created
• *600 (per project)*

Number of New Construction Jobs Created
• *From 500 to 700 (per project)*

Range of Leasable Retail Space
• *From 1,000 to 400,000 square feet*

Source: http://www.smartcentres.com

Recent statistics indicate that the shopping centre industry makes a significant contribution to the Canadian economy and exerts a strong influence on the urban landscape.

SCOPE OF THE SHOPPING CENTRE INDUSTRY IN CANADA

All centres are 40,000 square feet (sf) and over

SHOPPING CENTRE DATA	2003	2004	2005	2006
SHOPPING CENTRE STATISTICS				
Number of shopping centres	2,198	2,259	2,298	2,345
Total leasable retail area (million sf) *	396.4	411.8	423.4	432.7
New centre openings	75	61	39	47
New centre GLA (million sf)	16.2	15.4	11.6	9.3
CONTRIBUTIONS TO ECONOMY				
Shopping centre-inclined store sales (billion $) †	$218.6	$230.7	$242.1	$256.7
Percentage of total retail sales	66.0%	66.5%	65.8%	65.6%
Provincial sales tax revenues from shopping centres (billion $) †	$14.9	$15.6	$16.2	$16.8
Shopping centre-related employment (000s) ‡	1,372	1,409	1,455	1,495
Percent of total non-agricultural employment	10.4%	10.5%	10.6%	10.6%

* Gross Leasable Area (GLA)

† All sales and sales tax figures stated in Canadian dollars and are based on the North American Industrial Classification System (NAICS). In Canada, ICSC defines "shopping centre-inclined store sales" to be the sum of sales at Furniture stores; Home furnishings stores; Computer & software stores; Home electronics & appliances stores; Home centres & hardware stores; Building materials and garden stores; Supermarkets; Convenience and specialty food stores; Beer, wine & liquor stores; Pharmacies; Clothing stores; Shoe, clothing accessories and jewelry Department stores; Other general merchandise stores; Sporting goods, hobby, book & music stores; and Miscellaneous store retailers.

‡ ICSC developed shopping centre-related employment from NAICS-based Statistics Canada's Survey of Employment, Payroll and Hours (SEPH) for all non-farm employees. The selection of industries that make up this related series is based on retail and real estate activities that would be associated with the shopping centre industry. In addition to the series listed in the footnote above, it also includes employment in rental and leasing services (NAICS 532). This comprises establishments that provide a wide array of tangible goods in return for periodic rental or lease payment. Many of these establishments are located in shopping centres.

Sources: Monday Report on Retailers (Rogers Publishing), Ivanhoe Cambridge, Statistics Canada and ICSC Research

Figure 11. Shopping centre data for developments greater than 40,000 ft^2.
http://www.icsc.org/srch/rsrch/scope/canada/current/Canada_Summary07.pdf

Figure 12. Norgate Shopping Centre, Montreal, Québec. [Source: PharmaPrix.]

Canada's first strip mall or retail plaza development was Norgate Shopping Centre, in the borough of Saint-Laurent, Montreal, Québec. Designed by architect M. Kalman and constructed in 1949, the development is arranged in an L-shaped plan, wrapping around an open air parking lot, from which the stores were accessed. The first covered mall in Canada, the Park Royal, was built a year later in 1950 in Vancouver.

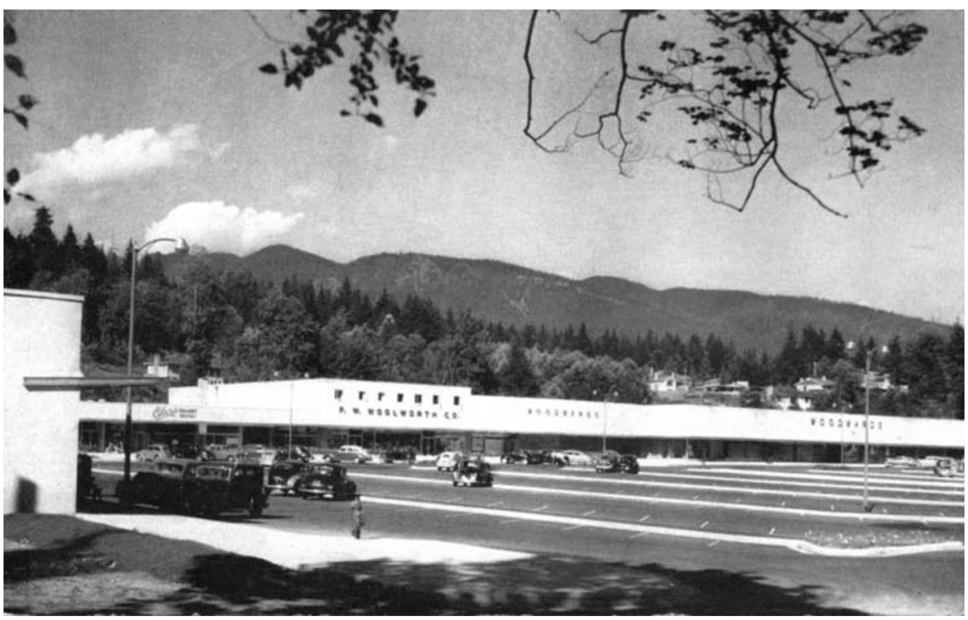

Figure 13. Park Royal Shopping Centre, Vancouver, British Columbia.
[Source: BC Archives.]

Baseline Retail Building

The baseline retail building model developed for this study reflects the range of characteristics for new developments of this kind. It is worth noting that there is no typical retail development. Industry experts claim the sizes, types and layouts vary according to market forces and availability of land. The model used in this study is a single storey development containing 80,000 ft^2 (7,435 m^2) of retail space, with 20,000 ft^2 (1,859 m^2) devoted to a restaurant/café. The building envelope components have the following effective thermal resistance values: roof R-20 (RSI 3.5), slab-on-grade floors insulated at perimeter R-10 (RSI 1.8); walls R-15 (RSI 2.6); windows R-1.8 (RSI 0.3). The retail spaces are conditioned using packaged single-zone rooftop units that use natural gas for heating and electricity for cooling. Mechanical ventilation does not employ heat recovery. A complete description of the building characteristics may be found in Appendix C of this report.

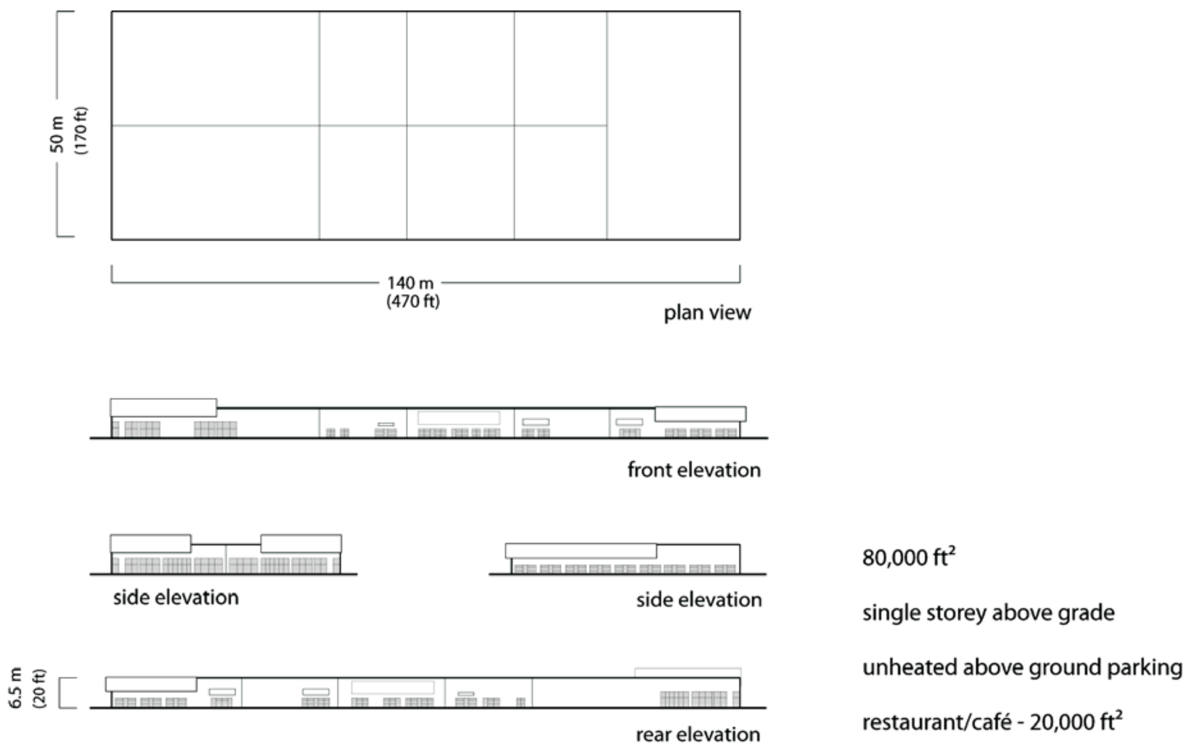

Figure 14. Model retail building used for energy simulation and cost-benefit assessment.

The retail baseline building was modeled in all cases using packaged rooftop units. Results of the cost-benefit analysis are presented in Table 12. A legend explaining the entries in the cost-benefit analysis may be found in Figure 9 on Page 48.

Retail Building Energy Conservation Cost-Benefit Analysis

The analyses presented in Table 12 are based on the same two interest (discount) rate and energy price escalation rate scenarios used for the MURB and office building models.

Table 12. Retail Building – Energy and Economic Assessment of Energy Conservation Measures

This analysis is based on an energy performance workshop conducted by EnerSys Analytics Inc.
Economic measures based on:
ASTM E 1057 Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems
ASTM E 1121 Measuring Payback for Investments in Buildings and Building Systems
ASTM E 917 Measuring Life Cycle Costs of Buildings and Building Systems

Effects of energy conservation measures (ECMs) on equipment downsizing have been applied.

Economic Assessment Parameters

Two interest (discount) rate and energy escalation rate scenarios are considered in this analysis.

	Current	*High*
Interest Rate	**5.5%**	**7.0%**
Energy Escalation Rate	**8.0%**	**12.0%**
Study Period (yrs)	**25**	**25**
	50	**50**
	75	**75**

			Annual	**Current**			**High**		
		Cost	**Savings**	**PB (years)**	**IRR**	**NPV**	**PB (years)**	**IRR**	**NPV**
Baseline		$0	$0	N/A	N/A	**$9,791,122**	N/A	N/A	**$13,601,142**
$142,761	Elec.					**$27,375,008**			**$56,203,290**
$142,006	Nat. Gas					**$58,953,927**			**$189,643,777**
1,093	T of CO_2e								
ECM #1	Improve window U-value by 26.7% and shading coefficient by 16.75% by adding low-e, argon, and a thermal break. Incremental cost is $4.00 per ft2.								
		$33,339	$4,640	6.6	22.4%	**$9,664,924**	6.1	26.9%	**$13,412,864**
$142,126	Elec.		1.63%			**$26,962,298**			**$55,320,851**
$138,001	Nat. Gas					**$58,026,670**			**$186,587,056**
1,072	T of CO_2e								
ECM #2	Improved window frames and glazing by adding low-e, argon, and a 9 mm thermal break. U-value is 48% better, shading coefficient is 40.5% better. Cost is $16.00 per ft2.								
		$135,766	$8,155	13.9	11.7%	**$9,646,495**	12.2	15.8%	**$13,347,406**
$140,994	Elec.		2.86%			**$26,726,824**			**$54,729,537**
$135,618	Nat. Gas					**$57,401,403**			**$184,348,629**
1,058	T of CO_2e								

The energy simulation and cost-benefit analyses for the base retail building estimate the annual energy costs to be $284,167, contributing 1,093 tonnes of greenhouse gas emissions. The net present value of the operating costs over a 25-year period is estimated as $9,781,122 under the current energy price escalation scenario, and $13,601,142 under the high scenario.

Improvements to window performance as indicated by ECMs #1 and #2 were found to be cost effective energy conservation measures. The minor performance upgrade in ECM #1 provides acceptable payback periods and rates of return. The major performance upgrade in ECM #2 provides reasonable payback periods and rates of return, but a lower life cycle cost than ECM #1. Investing $102,427 more than ECM#1 in high performance windows yields $18,429 more in life cycle savings under the current scenario, and $65,458 more savings under the high scenario.

ECM #3	Add 1" rigid insulation to opaque walls results in an improvement of R-5. Cost is $1.50 per ft2.								
		$35,041	$1,720	16.5	9.8%	**$9,767,024**	14.2	13.8%	**$13,554,032**
$142,755	Elec.		0.60%			**$27,244,703**			**$55,898,861**
$140,292	Nat. Gas					**$58,632,885**			**$188,533,365**
1,085	T of CO2e								
ECM #4	Add 1" rigid insulation to the roof results in an improvement of R-5. Cost is $1.25 per ft^2.								
		$98,397	$1,655	37.0	1.7%	**$9,832,615**	28.4	5.5%	**$13,620,492**
$142,622	Elec.		0.58%			**$27,314,308**			**$55,975,046**
$140,490	Nat. Gas					**$58,709,698**			**$188,640,008**
1,085	T of CO2e								

Improvements to the thermal resistance of exterior wall and roof assemblies are examined in ECMs #3 and #4. Adding 1-inch (25 mm) of rigid insulation with a thermal resistance of R-5 (RSI 0.88) to the walls reduces annual energy consumption by 0.60% and yields a payback period of 16.5 years, and an internal rate of return of 9.8% under the current scenario - 14.2 years and 13.8%, respectively under the high scenario. All life cycle costs are lower than the corresponding baseline values, but this measure may not be considered cost effective due to the relatively high payback period. It is important to note that given the useful life of modern buildings, and the high cost of retrofitting exterior walls, the added wall insulation may provide 50 or more years of service beyond the payback period. By contrast, ECM #4 indicates a payback period that likely exceeds the service life of the roof membrane. Additional insulation may be considered the next time the roof membrane is replaced, but this is not a practical option for walls. It should be recognized that the effective thermal resistance values for the walls and roof used in the energy simulations correspond to installed insulation levels of approximately R-25 (RSI 4.4) for walls and R-30 (RSI 5.3) for roofs.

ECM #5	Add 4 foot horizontal shading above all windows. No cost associated.								
		unknown	($105)	N/A	N/A	**$9,794,732**	N/A	N/A	**$13,606,157**
$140,901	Elec.		-0.04%			**$27,385,102**			**$56,224,013**
$143,971	Nat. Gas					**$58,975,665**			**$189,713,703**
1,097	T of CO2e								

ECM #5 examines the use of shading devices for windows, in the form of a 4-foot wide horizontal element over all the windows. This is a common practice in many retail malls where an awning-like structure is permanently attached to the building façade to provide shelter from rain. The fabric or lightweight metal skin often bears signage that displays the store's brand or identity. The analysis indicates that it costs $105 more in annual energy because the shading reduces solar gains that help warm the building during the heating season. The summer heat gains that are avoided by the shading do not outweigh the solar gains that are lost. Operable shading devices, such as retractable awnings, could be considered as a viable means of obtaining desired performance on a seasonal basis.

ECM #6	High efficiency DX cooling with 12 EER replaces the baseline 9 EER system. This results in a 21% improvement in energy efficiency.								
		$300,000	$5,670	34.1	2.5%	**$9,896,171**	26.6	6.3%	**$13,630,329**
$137,091	Elec.		1.99%			**$27,129,944**			**$55,384,225**
$142,006	Nat. Gas					**$58,080,095**			**$186,167,777**
1,082	T of CO2e								
ECM #7	Replace on/off burners with modulating burners. $1,500 per MBH incremental savings.								
		$10,500	$14,032	0.7	152.3%	**$9,319,161**	0.7	161.7%	**$12,941,441**
$142,761	Elec.		4.93%			**$26,036,594**			**$53,444,352**
$127,974	Nat. Gas					**$56,059,450**			**$180,309,509**
1,027	T of CO2e								
ECM #8	Replace on/off burners with condensing type burner section. Costs based on $9,000 per million BTU.								
		$63,000	$25,384	2.4	51.5%	**$8,981,346**	2.3	57.1%	**$12,451,742**
$142,761	Elec.		8.91%			**$24,997,813**			**$51,256,354**
$116,622	Nat. Gas					**$53,761,801**			**$172,802,018**
975	T of CO2e								
ECM #9	Demand Control Ventilation (50% applicability). Add a CO2 sensor to the return air of each roof top unit. Cost is $1,500 per sensor installed and calibrated.								
		$37,500	$32,304	1.1	101.0%	**$8,717,916**	1.1	108.5%	**$12,095,727**
$144,028	Elec.		11.34%			**$24,307,084**			**$49,865,082**
$108,435	Nat. Gas					**$52,303,687**			**$168,168,066**
942	T of CO2e								
ECM #10	Add a 75% efficient air-to-air heat recovery system to each roof top unit.								
		$144,590	$6,576	17.6	9.1%	**$9,709,610**	15.0	13.1%	**$13,431,647**
$140,191	Elec.		2.31%			**$26,887,439**			**$55,050,002**
$138,000	Nat. Gas					**$57,737,120**			**$185,409,006**
1,070	T of CO2e								

Improvements to the efficiency of HVAC equipment represent the most common energy conservation measures employed in retail developments. ECM #6 examines improving the efficiency of the cooling system in the packaged rooftop units. All of the economic measures strongly indicate this is not cost effective based on the premium associated with the upgrade. ECMs #7 and #8 look at improving the efficiency of the gas burner in the rooftop units. In both the case of the modulating burner and the condensing burner upgrade, these measures are highly cost effective. The condensing burner upgrade provides a significantly lower life cycle cost than the modulating burner upgrade, and this technology has a sufficiently lengthy service life to realize these savings.

Demand control ventilation was applied to 50% of the retail building model and the results indicated this was an extremely effective energy conservation measure. Heat recovery was examined in ECM #10 and while this measure falls within a reasonable threshold of cost effectiveness, it is not as cost effective as demand controlled ventilation. Note that in this case, heat recovery was applied after the implementation of demand controlled ventilation, hence the volume of ventilation air is much lower than the amount resulting from continuous operation of the ventilation system.

Energy conservation measures for lighting were not considered in this building model. The retail industry relies on lighting as a means of illuminating merchandise and lighting practices usually originate with the tenant rather than the developer. Retail lighting is becoming more energy efficient, but there are cases where the nature of the business demands a high degree of electrical energy consumption that is difficult to avoid, such as lighting stores, or big box electronics outlets. Outdoor illumination is also another aspect of retail strip mall developments that was not examined. For reasons of security, the parking areas are fully illuminated during evening business hours. Timers, photocells and more efficient lamps and luminaires to reduce energy consumption by outdoor lighting are readily available in the marketplace.

Combo A	ECM #1 + ECM #3 + ECM #9 + ECM #7								
		$207,045	$58,679	3.4	38.5%	**$7,980,612**	3.2	43.7%	**$11,005,540**
$141,740	Elec.		20.61%			**$21,941,167**			**$44,829,102**
$84,348	Nat. Gas					**$47,012,944**			**$150,772,884**
827	T of CO2e								
Combo B	Combo A with glazing improvement and heat recovery (ECM #2 + ECM #3 + ECM #9 +ECM #7 + ECM #10)								
		$353,199	$65,014	5.1	27.6%	**$7,908,950**	4.8	32.3%	**$10,849,119**
$139,118	Elec.		22.83%			**$21,478,330**			**$43,724,943**
$80,635	Nat. Gas					**$45,847,594**			**$146,700,174**
807	T of CO2e								
Combo C	Combo A with condensing burners vs modulating type (ECM #1 + ECM #3 + ECM #9 +ECM #8)								
		$259,545	$66,113	3.7	35.4%	**$7,777,509**	3.5	40.4%	**$10,702,974**
$141,740	Elec.		23.22%			**$21,279,028**			**$43,414,384**
$76,914	Nat. Gas					**$45,526,419**			**$145,874,628**
794	T of CO2e								

Combo A examines a minor improvement to window performance, added wall insulation, demand controlled ventilation and modulating gas burner in packaged rooftop units. The $207,045 incremental cost yields $58,679 in annual energy savings. The payback period is 3.4 years with an internal rate of return of 38.5% under the current scenario, 3.2 years and 43.7% respectively under the high energy price escalation rate scenario. For a 25-year period, the life cycle savings are approximately $1.81 million under the current scenario and almost $2.6 million under the high scenario.

Combo B is the same as Combo A, but with major improvement to windows and the addition of heat recovery. It costs more initially, but saves more energy and delivers lower life cycle costs. It also reduces peak electrical energy demands more than any of the combinations of measures, as will be discussed in the next part of this report.

Combo C is the same as Combo A but with condensing burners in the packaged rooftop units. Combo C has the best balance between initial costs, payback period, rate of return and life cycle cost. Combo B reduces peak electrical energy demand through more efficient windows that reject heat gains and heat recovery that reduces ventilation loads.

Table 13. Retail Strip Mall Statistics

Building Areas	ft^2	m^2	***Building Envelope***	ft^2	m^2
Gross Floor Area	80,000	7,436	Roof Area	80,000	7,436
Restaurants/Cafes	20,000	1,859	Gross Wall Area	32,150	2,988
			Opaque Wall Area	23,500	2,184
			Window Area	8,650	804
			Percent Glazing	27%	27%

Energy & Conservation Measure Data

	Annual Energy Intensity		**Annual Energy Costs**		**Cost Premium**	
	BTU/ ft^2	kWhe/ m^2	\$/ ft^2	\$/ m^2	\$/ ft^2	\$/ m^2
Baseline Building	196700	620	\$3.56	\$38.31	\$0.00	\$0.00
Combo A	136300	430	\$2.83	\$30.42	\$2.59	\$27.84
Combo B	132000	416	\$2.75	\$29.57	\$4.41	\$47.50
Combo C	128700	406	\$2.73	\$29.42	\$3.24	\$34.90

	GHG Emissions			**Peak Electrical Demand Reductions (kW)**		**Avoided Costs**
	Tonnes	Reduction	%	Max	%	@\$1,500/kW
Baseline Building	1,093	0	0	0	0.0%	0
Combo A	827	265	24.3%	7	1.1%	\$10,500
Combo B	807	286	26.2%	68	10.7%	\$102,000
Combo C	794	299	36.1%	7	1.1%	\$10,500

Baseline peak demands - Heating N/A, Cooling 468.7 kW (July), Max 638 kW (July)

Table 13 provides summary statistics for the baseline retail building and the three combinations of measures examined. Due to the higher intensities for retail buildings compared to MURBs and office buildings, the annual energy savings per unit of floor area are the highest among the three building typologies assessed. The peak electrical energy demand for Combo B yields the highest avoided costs, and when these are taken into consideration at a rate of \$1,500 per kW, the cost of Combo B would fall to \$3.14/ft2, slightly lower than Combo C. The best combination from a societal perspective (life cycle costs) was assessed as being Combo C, but when the avoided costs are considered, it is likely that Combo B would have an overall lowest life cycle cost. While a fourth combination was not examined, it is likely that Combo B with condensing burners is the most cost effective recipe for retail buildings. Differences in performance aside, an integrated combination of energy conservation measures is definitely cost effective for all of the three combinations examined for retail buildings.

Synopsis for Energy Conservation Measures in Retail Buildings

Retail buildings are more energy intensive than MURBs and office buildings because the form of the buildings is typically single storey and the amount of building envelope relative to the floor space is the highest of all building types examined. Lighting loads are also higher on a unit floor area basis, and ventilation rates correspond to a large commercial occupancy. More recently, hours of operation have expanded with many stores staying open until 9 PM every weekday, as well as having extended weekend hours. Together, these factors cause retail buildings to have among the highest energy intensities (annual energy consumption per unit of conditioned floor area), second only to health care facilities. The assessment of energy conservation measures in retail buildings has been summarized as:

- Glazing areas for merchandising display are very generous in retail buildings, hence it is cost effective to deploy high performance windows. Retail buildings in a strip mall setting typically have glazing on one façade only, and the solar heat gain coefficient of the glass should be selected according to solar orientation.
- The relatively straightforward construction and detailing of retail building facades makes them ideal candidates for improving the effective thermal resistance of building envelope assemblies. Installed insulation levels of approximately R-25 (RSI 4.4) for walls and R-30 (RSI 5.3) for roofs should be accepted as minimum, cost effective levels.
- Lighting energy conservation was not examined as this varies according to the retail tenant. Several of the cost-benefit studies cited earlier have recommended the use of skylights, or other appropriate forms of daylighting, to reduce energy consumption and improve the retail atmosphere. The lighting industry continues to conduct research and development of efficient lamps and luminaires for commercial purposes. The use of LED sources for signage is a recent development that reduces energy consumption and life cycle costs. Parking lot and exterior security lighting continue to represent a missed energy conservation opportunity in most retail developments.
- Investments in equipment efficiency were shown to be highly cost effective. High efficiency burners in packaged rooftop units, demand controlled ventilation and heat recovery are the most reliable investments that reduce energy consumption and peak electrical energy demands.
- Retail developments are premised on showcasing products and catering to peak shopping schedules. There are many time periods when the buildings have practically no occupancy and the parking lots are almost empty. Yet, as shall be seen in the final section of this report, retail strip malls can be made very energy efficient and due to their large roof areas, become ideal hosts for renewable energy technology platforms.

Low-Rise Residential Buildings

This study did not include low-rise residential buildings as part of the energy performance workshop series because there has been an extensive body of research conducted over the past decade on cost effective energy conservation measures in this form of housing. Low-rise housing is defined as single-family detached houses, doubles (semi-detached) and row or townhouses up to three storeys in height. The most significant difference between low-rise housing and other buildings is that since the time of the 1970s energy crisis, its energy efficiency has steadily improved.

Single-family detached housing is the predominant residential building typology in the GTAH. Referring to the statistics presented earlier in Table 7, single-family detached housing represented nearly 50% of all housing starts from 2001 to 2006. Forecasts for the period 2007-2031 indicate this trend is likely to continue.

Energy efficiency requirements for houses under the Ontario Building Code (OBC) apply to all low-rise residential buildings. After 2012, new houses will be required to meet standards substantially in accordance with the national guideline, EnerGuide 80. This practically translates into a 35% reduction in energy use compared to houses constructed under the 1997 OBC, and it is expected these measures will add $5,900 to $6,600 to the price of a typical 2,000 ft^2 gas-heated home, yielding a 6.9 to 7.9 year payback.

Voluntary Energy Efficient Housing Programs in Canada

Parallel to these legislated minimum requirements for energy efficiency are several voluntary standards and programs for energy efficient house construction. Many of these voluntary standards embody additional requirements for improved indoor air quality, materials selection and water conservation, among other environmental measures.

R-2000 Program

The R-2000 Standard was introduced in 1981 and includes requirements related to energy efficiency, indoor air quality and the use of environmentally responsible products and materials. It does not, however, specify exactly how a house must be built. Rather, the R-2000 Standard sets criteria for how an R-2000 home must perform. This leaves the designer and builder free to choose the most effective and economical way to build it.

The R-2000 Standard is supported by an extensive program of research, development and testing. Natural Resources Canada's team of technical experts – in consultation with industry technical experts – reviews the R-2000 Standard regularly. Before changes to the R-2000 Standard are adopted, thorough testing is carried out. Once the Standard is changed, home builders and other industry professionals receive training updates.

The R-2000 Standard sets out a series of house performance requirements that are in addition to those required by building codes. In general terms, the R-2000 Standard involves the following:

Builder's licence: Only home builders who have completed R-2000 builder training and hold a current R-2000 builder licence can build homes that can be certified to the R-2000 Standard.

Energy budget: R-2000 homes must operate within a specific energy budget, based on the characteristics of the home and the climate conditions where it's built. Typically, R-2000 homes need 30 percent less energy to operate than conventional new homes. Common in R-2000 homes are additional insulation; double-glazed, low-emissivity, gas-filled windows with insulated spacers; and high-efficiency heating systems.

Whole-house ventilation: Every R-2000 home must have a whole-house ventilation system that supplies fresh outdoor air to all living areas in the home. This system must be designed and tested to meet the CSA International standard CAN/CSA-F326 M91 ("Residential Mechanical Ventilation Systems"). Installers must be trained by the Heating, Refrigeration and Air Conditioning Institute of Canada, or equivalent. After renewing the latest building research and any new technologies on the market, a technical review committee initiates potential changes to the Standard within Natural Resources Canada.

Environmental pick list: Every R-2000 home builder must choose from a "pick list" of options for indoor air quality and environmental features. The indoor air-quality features can include items such as hardwood flooring, low-emission cabinetry, low-emission (low volatile organic compound [VOC]) paints, and non-solvent-based adhesives and finishes. Features to conserve materials include choices for insulation, siding, sheathing, wall studs and foundation drainage.

Cleaner heating: The heating systems in the home must not be susceptible to combustion spillage.

Water conservation: Every R-2000 home must be equipped with water-conserving toilets, faucets and shower heads.

Independent inspections: Every home submitted for R-2000 certification must undergo a series of independent inspections and tests to verify that the requirements of the R-2000 Standard have been met.

EnerGuide for New Houses

An EnerGuide for New Houses rating is a standard measure of a home's energy performance. It indicates the energy efficiency level of the home to owners (and future buyers).

A home's energy efficiency level is rated on a scale of 0 to 100. A rating of 0 represents a home with major air leakage, no insulation and extremely high energy consumption. A rating of 100 represents a house that is airtight, well insulated and sufficiently ventilated and requires no purchased energy. For a brand new house, a rating of 80 or higher is considered very energy efficient, at or near the level of a typical R-2000 home.

EnerGuide for Houses Rating Chart	
Type of House	**Rating**
Older house not upgraded	0 to 50
Upgraded old house	51 to 65
Energy-efficient upgraded old house or typical new house	66 to 74
Energy-efficient new house	75 to 79
Highly energy-efficient new house	80 to 90
An "advanced house" that uses little or no purchased energy	91 to 100

Table 14. Range of EnerGuide house ratings based on Canadian house types.

[Source: EnerGuide for Houses Program, Office of Energy Efficiency, Natural Resources Canada.]

The EnerGuide for New Houses rating is calculated by a professional EnerGuide for New Houses energy advisor using information collected from the following: an analysis of the building plans before the home is built; and results of the blower door test performed after the house is built. The advisor works with details about the home's energy systems, construction materials and assembly, and uses a modeling software program developed for this purpose by Natural Resources Canada. To ensure the rating reliably measures how the house itself uses energy, irrespective of the occupants' energy-using habits, the calculation is based on the house having the following standard operating conditions:

- four occupants
- a thermostat setting of 21°C (70°F) on main floors and 19°C (66°F) in the basement
- a total domestic hot water consumption of 225 litres per day
- lighting and appliance electricity consumption of 24 kilowatt hours per day
- a minimum monthly average ventilation rate of 0.35 air change per hour during the heating season

Once construction of a home is completed and the advisor has performed the final evaluation, the owner receives the EnerGuide for New Houses label.

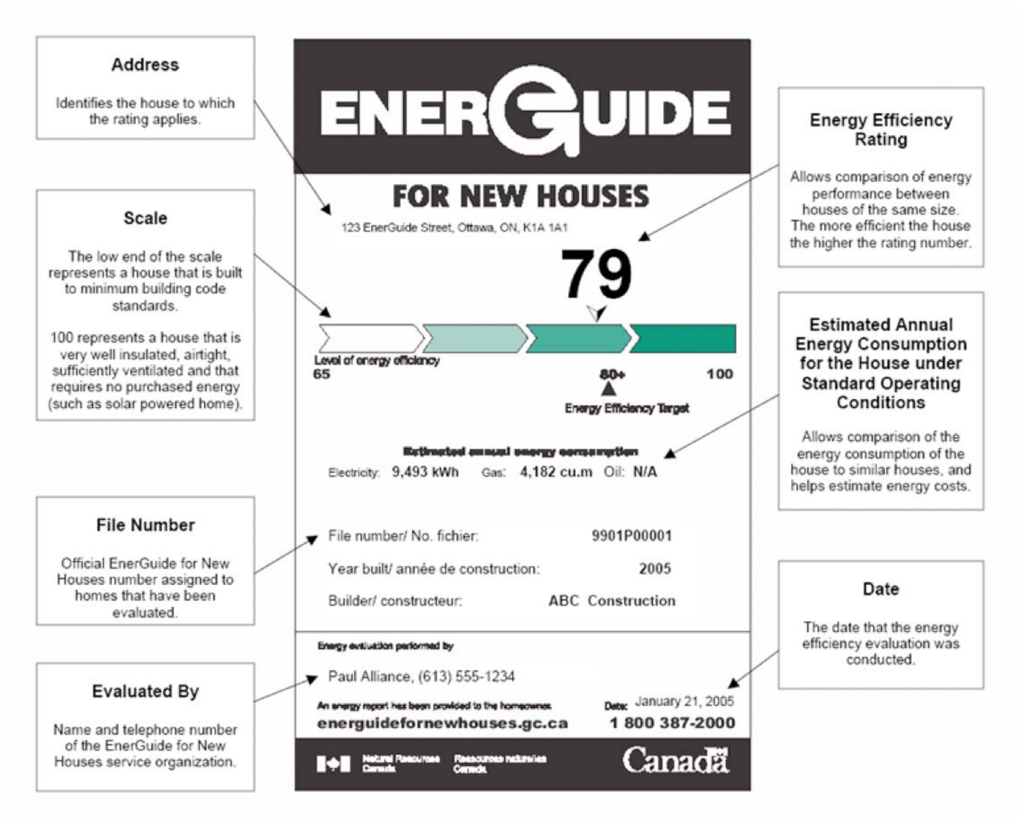

Figure 15. Typical EnerGuide for New houses rating label.

[Source: Office of Energy Efficiency, Natural Resources Canada. http://oee.nrcan.gc.ca/residential/personal/new-homes/upgrade-packages/label.cfm?attr=0]

Regional residential energy efficiency initiatives are building standards that have been set up across Canada in cooperation with the home building industry to implement the EnerGuide for New Houses Program. These initiatives set up guidelines and standards for home builders to meet so that they can reach a minimum EnerGuide rating. Once a home has been built according to the initiative's specifications, the homeowner receives a certificate and/or home label that identifies the home as being built to the regional energy efficiency standard.

All of the initiatives have the united goal of increasing the energy rating and energy efficiency of new homes in Canada. However, each initiative is created independent of the others and has a unique and creative way of encouraging energy efficient home building that is tailored to the new housing market in their region.

In summary, EnerGuide for New Houses is a national initiative that allows builders to work with an energy advisor to increase the energy efficiency of a home by making energy conscious adjustments to the house plan before it is built. Implementing these energy efficiency changes is voluntary and the house does not need to meet a minimum EnerGuide rating.

R-2000 is a national initiative that requires homes to be built using environmentally friendly and renewable products. It includes comprehensive training and certification for homebuilders, as well as quality assurance inspection, testing and certification of new houses to guarantee that they meet the R-2000 Standard. R-2000 homes are about 30 percent more energy efficient than conventional new homes and must achieve a minimum energy efficiency rating of 80 on the EnerGuide rating scale. Regional initiatives provide options for builders who would like to increase the EnerGuide rating of new homes by following an energy efficient building standard other than R-2000. Each initiative is created independent of the others and encourages energy efficient home building in a way that is tailored to the new housing market in their region.

Voluntary Standards and Programs for Energy Efficient New Housing in Canada		
Program	***Implementation***	***Minimum EnerGuide Rating***
R-2000	Canada	80
EnerGuide	Canada, and as noted below	varies by program (see below)
Energy Star	Ontario, Saskatchewan	80
GreenHome	Yukon Territory	80
Novoclimat	Quebec	78
Power Smart	Manitoba	77
Built Green	Alberta, British Columbia	72-77

Table 15. Summary of voluntary programs and standards for the construction of energy efficient housing in Canada.
[Source: EnerGuide for New Houses Program, Office of Energy Efficiency, Natural Resources Canada.]

The relationship between the EnerGuide for Houses rating and the average annual energy consumption per household is represented in Table 16. It is important to note that the EnerGuide for Houses rating scale is non-linear, and reflects the diminishing effectiveness of energy conservation measures on energy consumption in housing.

Average Energy Consumption per Household, Pre-1946 to 2000-2004		
Year built	***Average Energy Consumption (GJ)***	***EGH Rating***
Pre-1946	295	45
1946-1960	220	58
1961-1970	211	61
1971-1980	202	63
1981-1990	191	66
1991-2000	167	70
2001-2004	156	73
All EGH in Canada	216	60
R-2000	100	82

Table 16. Estimate of average annual household energy consumption and EnerGuide for Houses (EGH) rating by year of construction.
[Source: Appendix 2: Improving Energy Performance in Canada – Report to Parliament Under the Energy Efficiency Act - 2003-2004, Office of Energy Efficiency, Natural Resources Canada. http://www.oee.rncan.gc.ca/corporate/statistics/neud/dpa/data_e/parliament03-04/appendix2.cfm?attr=0#graph8]

Based on Table 15, new houses in Canada annually consume an average of 156 GJ total energy. R-2000 homes consume approximately one-third less energy than a typical new home. The chief advances in energy efficiency for R-2000 houses are due to increased thermal efficiency of the building envelope (insulation, airtightness, windows), increased efficiency of heating equipment (heat recovery) combined with lower hot water consumption, and more efficient appliances and lighting. The breakdown for the proportion of residential energy end use according to space heating, water heating, appliances, lighting and space cooling for R-2000 houses remains comparable to new conventional houses.

Energy Labeling - Canada

Home energy rating systems (HERS), or energy labeling, are entirely voluntary in Canada, but are becoming an increasingly important means of encouraging energy efficient house construction. In Canada, there are essentially two well established energy labeling programs: R-2000 and EnerGuide for New House (EGNH). As was noted previously, EnerGuide for New Houses has a number of initiatives in various Canadian provinces, and all of these reference the Energuide for Houses rating to establish compliance with energy performance. All of these programs also have requirements that go beyond energy efficiency and consider occupant health and environmental responsibility.

It is important to recognize that the primary role of energy labeling programs is to provide third party certification that a particular standard of construction has been achieved by a builder. For the homebuyer, the quality assurance provided by a recognized energy labeling program serves as an incentive to pay the additional cost of improved energy conservation measures, because these deliver energy savings and thereby a return on investment. Homebuyers may also qualify for special mortgages that consider the lower energy costs, and command a higher re-sale value for their home because of its energy efficiency. For the builder, energy labeling is a means of gaining a marketing advantage by having the quality of their house construction independently verified through a recognized labeling program. There are several, critical considerations from the builder's perspective:

- Do consumers recognize and trust the energy labeling program, and do they understand its costs and benefits?
- Are the administrative and technical requirements of the energy labeling program manageable within day-to-day operations?
- Are the added costs for administration and improved energy conservation measures recoverable without driving the labeled houses beyond a competitive price point?

In general, all three of these critical considerations must be favourably resolved for builders to enrol their homes in an energy labeling program.

R-2000 Program

Canada's leading super energy efficient housing program spawned the "house as a system" concept among Canadian homebuilders. The R-2000 Program was created in 1981 as a partnership between the Canadian Home Builders' Association and Natural Resources Canada. Since then, thousands of R-2000 homes have been built, and thousands of building professionals trained. R-2000 technology has enjoyed tremendous international success. Early on in the Program, R-2000 was "exported" to Japan as well as the US where it had a great influence on the evolution of energy-efficient construction. R-2000 homes have also been built in Poland, Russia, Germany, and most recently, England, as a collaboration between Canadian builders and British developers.[46]

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[46] *Welcome Home to R-2000*. Canadian Home Builders Association. http://r2000.chba.ca/What_is_R2000/brief_history.php

Figure 16. The R-2000 logo represents Canada's most notable effort to advance energy efficient new house construction.

Known primarily for its acceleration of the diffusion rate for energy efficient housing technology across Canada, the market penetration of the R-2000 program has not enjoyed similar success.

Year	Number of R-2000 Houses Constructed
1990	495
1991	699
1992	1196
1993	1299
1994	784
1995	610
1996	416
1997	484
1998	265
1999	213
2000	319
2001	329
2002	428
2003	379
2004	582
TOTAL	**8498**

Table 17. R-2000 housing starts 1990 to 2004.

[Source: Improving Energy Performance in Canada – Report to Parliament Under the *Energy Efficiency Act* For the Fiscal Year 2004-2005. Office of Energy Efficiency, Natural Resources Canada. http://oee.nrcan.gc.ca/Publications/statistics/parliament04-05/index.cfm]

From 1990 to 2004, CMHC estimated a total of 1,436,551 single housing starts. R-2000 housing starts over this same time period represent approximately 0.6% of total single housing starts.[47]

[47] *Single Housing Starts, Canada, Provinces and Metropolitan Areas, 1990–2005* (units). Canadian Housing Observer, Canada Mortgage and Housing Corporation. http://www.cmhc-schl.gc.ca/en/corp/about/cahoob/data/data_002.cfm

EnerGuide for New Houses and Energy Star
A recent study of energy labelling in Ontario presents the most extensive perspective on the contemporary Canadian experience comparing Energy Star, R-2000 and EnerGuide for New Houses. The italicized text which follows highlights key findings.

One in four Canadians said they recognized the ENERGY STAR brand and 40% said they recognized the EnerGuide label in a poll conducted for Natural Resources Canada by the Ipsos-Reid Corporation in June 2005. When the same respondents were asked what they thought the meaning of the EnerGuide label represented, 43% most commonly said that it showed the energy use of an appliance. However 27% also believe it meant the product was energy efficient and 24% thought it meant the item saved energy.

In the same study, between 80-82% recognized that the ENERGY STAR brand represents energy efficient, low energy consumption or energy savings. This response was distantly followed by 13% who thought the symbol implies the product is cheap and by 11% who thought the item was environmentally friendly.

It would appear that the existing EGH and EGNH voluntary programs have room for improvement to be more effective in selling energy efficiency upgrades. For instance, penetration rates of voluntary labeling of existing homes in Ontario are limited relative to the size of the housing stock. Of Ontario's 2.8 million single homes, only 75,000 (2.7%) have had an EGH audit and about 44,800 (1.6%) new homes in Ontario are currently being EGNH rated.

In 2005, Natural Resources Canada expanded the ENERGY STAR Initiative in Canada to include energy-efficient new homes being built in Ontario. ENERGY STAR qualified new homes are approximately 30 to 40 percent more energy efficient than those built to minimum Ontario Building Code standards.

The program has so far exceeded all expectations in the first phase of the pilot in terms of consumer uptake and market impact. With modest initial pilot goals, the program is now being promoted by over 100 builders in Ontario, the majority of which are among the largest production builders and many are high profile builders in the Barrie, GTA, London, Oshawa, and Ottawa markets. Uptake from key builders in Windsor and Kingston show signs that these markets will soon be significantly impacted as well. The key to the success of ENERGY STAR, was opposed to the more limited impact of R-2000 in Ontario and to some extent EGH and EGNH, has been the brand recognition of the label, with over 1 billion products bearing its mark across 45+ product categories and it appears to be the most recognizable brand in energy efficiency.

In the past, R-2000 was the premiere energy target for new homes. R-2000 is an initiative that Natural Resources Canada introduced over 20 years ago. R-2000 like ENERGY STAR, has a minimum energy efficiency requirement of 80 on the EGNH scale. Certification is achieved through a comprehensive series of third party inspections that ensure that all energy efficiency, indoor air quality, environmental and safety standards of the home are met. The uptake remained limited because consumers were unfamiliar with the product and did not know what to ask for. Also, cost to builders is significantly higher than ENERGY STAR, since R2000 builders are charged an annual licensing fee beyond file management costs and the registration fees for each home.

Also, in a survey conducted by Compas for Natural Resources Canada in March 2002 to better understand the motivations of builders for becoming and remaining active R2000 builders, less than one quarter build all their houses to the standard and almost half of them stated that one or more of the houses they have built were built to the standard but were not certified. The most often cited reason for not certifying these houses, was that the cost to certify adds too much to the price of the home and their customers would not pay for it.

Benefits to homebuilders in joining the ENERGY STAR program include:

- *Rendering competition obsolete (builders can attract buyers looking for a home that will cost them less to own and help protect the environment)*
- *Increasing revenues (the monthly savings that buyers will receive allows them to budget for more builder upgrades)*
- *Increasing consumer satisfaction (comfort, quiet and savings decrease buyer remorse after the sale while making the buyer a life-long customer)*
- *Reducing risk (proven reduction in quality-related call backs; government-backed label).*

Furthermore, ENERGY STAR having already cultivated recognition for its 'best in class' demarcation, has made it easier for builders and sales agents to educate and inspire consumers; but more powerfully, it generates media awareness and potential homebuyers know to ask for it. Extensive media coverage and satisfaction from having had a positive experience with an ENERGY STAR product purchase seem to be significant factors that have driven the uptake in ENERGY STAR home sales in Ontario, as have the supporting mechanisms to builders including training both to builders and sales agents, marketing tools, access to certified advisors and incentives.

It is clear to most industry experts that there is an increased desire for energy efficiency among Ontario homebuyers and those programs that can more easily and affordably meet this consumer need by educating and inspiring consumers will be the most successful.

The ENERGY STAR brand's success in market transformation, proves to be an excellent example of how labeling can both increase public awareness as well as motivate sustained energy efficient behaviour without necessitating the creation of regional infrastructure for energy efficiency, since accurate information to consumers is transferred through partnering organizations including retailers, utilities, energy groups, builders and manufacturers but also because the prescribed standard allows builders to avoid some of the problems associated with the EnerGuide measurement software that may give different ratings for an identical house.

If a mandatory labeling program is to be initiated by the Province of Ontario, its key focus should be the sale and marketing of energy efficient products. While a mandatory label cannot give special preference to builders and homeowners who participate, like the current voluntary labels do, it can reward higher levels of energy efficiency by marketing these levels as being more desirable and more beneficial. There are at least five benefits that come from energy efficient upgrades:

1. *utility cost reduction,*
2. *increased comfort,*
3. *better quality product,*
4. *improved indoor environment quality, and*
5. *lowered environmental impact.*

All of these should be available to builders, manufacturers and homeowners who use a mandatory label and achieve superior ratings. The label itself will be of little value without a coherent information marketing campaign designed to preference those who rate higher.[48]

[48] *Research Findings Regarding the Potential for Improved Energy Efficiency Through Mandatory Labeling of New and Existing Housing in Ontario*. Adriana Dossena, Lenard Hart and Stephanie Thorson, Climate-Air Connections, Toronto, March 22, 2006. http://www.climateairconnections.ca/pdf/Mandatory_Labeling.pdf

The typical Energy Star house constructed in Ontario has an annual energy consumption similar to that shown for R-2000 houses in Figure 17. According to EnerQuality which manages the Energy Star Homes program in Ontario, these houses do not bear any appreciable cost premium, and the energy savings more than pay for the incremental costs, making this investment neutral in terms of affordability from a consumer and financial institution perspective. It is now technically possible to reduce energy demands in housing to a threshold which can be satisfied with renewable energy sources, as being demonstrated by CMHC's Equilibrium houses project. The goal of the net-zero energy home is a near-term reality. Even without this attainment, new low-rise residential housing with an annual energy intensity of approximately 150 $ekWh/m^2$ is the most energy efficient building typology being constructed in the GTAH.

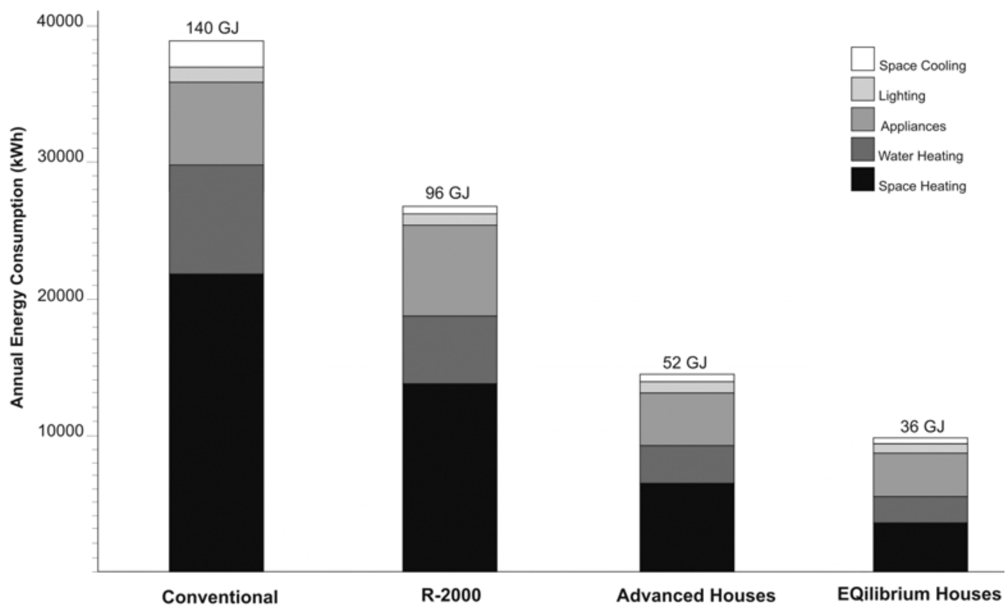

Figure 17. Typical annual energy consumption for conventional new houses and energy efficient houses.

[Sources: *Tools for the Design of Zero Energy Solar Homes*. R. Charron, A. Athienitis, and I. Beausoleil-Morrison. 30th Annual Conference of the Solar Energy Society of Canada, Vancouver, August 2005. Equilibrium house data as of January 2007 provided courtesy of Canada Mortgage and Housing Corporation. Note: EQulibrium houses annual energy consumption is reported as annual energy demand before application of renewable energy contributions, hence actual energy consumption is expected to be lower.]

Synopsis for Energy Conservation Measures in Low-Rise Residential Buildings

The Toronto Green Development Standard already promotes Energy Star rated houses as a means of complying with its energy efficiency requirements. When higher levels of energy efficiency come into effect by 2012 for houses under the Ontario Building Code, the Energy Star for New Home Program is expected to provide new homebuyers with an even higher, but equally cost effective, level of energy efficiency. Energy labeling is key to the Energy Star for New Homes Program marketing success. Third-party certification of energy efficiency enables financial institutions to confidently extend financing incentives that recognize that lower energy bills will offset slightly higher mortgage payments. Government agencies that may be interested in providing further incentives can also rely on the level of energy efficiency actually being delivered by builders to consumers.

A recent study conducted by the Pembina Institute provided recommendations to improve energy efficiency requirements for new housing in Ontario:

Program 1: New Housing Energy Efficiency

The goal of this program is to greatly increase the number, types and profiles of high-efficiency Energy-Star and other homes being built in Ontario — adding significantly to the small number of projects currently under way in Mississauga, Ottawa and other cities. The objective is to achieve 65% market share for homes with an EnerGuide for Houses (EGH) rating of greater than 80 by the end of 2009 — of which 25% would have solar water heaters and 5% would be net-zero-energy homes. The program would have several elements, including the maintenance of a province-wide directory of certified Energy-Star home builders, an Energy-Star home-buyers' kit, annual awards and a conference for Energy-Star building achievements, certification of homes with an Energy Star/EGH 80 rating, and a series of financial incentives for both the builder and the home buyer. The Home-Buyers' Kit would include information on the benefits of Energy-Star homes, standard specifications for Energy-Star features, the importance of having an HRV and solar-readiness package, the requirements that must be met by the builder, options for adding a solar water heater and other components for a net-zero-energy home.

Financial incentives for the builder would consist of a sliding scale of rebates based on the EGH rating for the new house, starting at $2,000 for EGH 80 up to $5,000 for a net-zero-energy home. Rebates would be provided only for homes that receive EGH 80+ certification, that use only natural gas or solar water heating, and that meet other green building-requirements such as solar readiness (attic to basement wiring and plumbing channels, and on-site power interconnections) and the installation of a heat recovery ventilator (HRV). Financial incentives for home buyers would include a reduction in CMHC mortgage insurance and sales tax rebates for Energy-Star appliances purchased for the home.[49]

Energy labeling, combined with cost effective energy efficiency measures, appear to be a proven formula for achieving the highest levels of energy efficiency among all building types examined in this study. With some 10,000 Energy Star homes registered in Ontario, and sharply rising energy prices, there may be little need for incentives and rebates, except for renewable energy technologies. Condominiums, offices and retail developments, which tend to employ more sophisticated architectural and engineering consulting services than home builders, have somehow failed to achieve comparable energy efficiency improvements. They obviously stand to gain important lessons from Ontario's low-rise residential construction industry.

[49] *A Quick Start Energy Efficiency Strategy for Ontario*. Mark S. Winfield, Roger Peters, and Stephen F. Hall, Pembina Institute, April 2006. http://energy.pembina.org/pub/218

Urban Site Technologies

Green development goes beyond green buildings. In order to function as intended, buildings demand services that are often referred to as urban site technologies. These site technologies are substitutes for the ideal site conditions that would have supported a pre-industrial era farmhouse. A woodlot would have provided a renewable source of energy, and a river or stream would not only serve as a source of drinking water, but could power a water wheel to mechanize tedious chores. The surrounding landscape was the source of all food, farmed, gathered or hunted. This landscape managed stormwater and also received and processed human waste. Garbage had not been invented as we know it today, with most discarded items being re-used or incinerated. Transportation was either local, using horses to pull wagons and sleighs depending on the season, or regional/international requiring a train or ship to cover the distances now routinely traversed by automobiles and planes. The stars and the moon were the only source of outdoor lighting, and also assisted wayfinding. Given the low densities of agrarian settlements, the environment was able to cope with human interventions, whose ecological footprint remained much smaller than nature's carrying capacity. All of this changed when large urban settlements came into being. That which had been provided by nature to each building site now had to be artificially delivered through urban site technologies.

> *"What is the use of a house if you haven't got a tolerable planet to put it on?"*
>
> **Henry David Thoreau**

This study maintains its focus on the notion of "building better" and examines all of the measures that can be addressed by those involved in building development. It should be recognized that larger issues, like urban transportation, energy and food production, may impact the environmental drivers to a higher extent than urban site technologies, but these remain beyond the control of individual stakeholders. A summary of the various measures responding to the TGDS environmental drivers is provided in Table 18.

Table 18. Various measures addressing the environmental drivers forming the Toronto Green Development Standard.

Environmental Driver	Green Development Measures
Better Air Quality	▪ Urban planning (mixed-use, intensification, live-work) ▪ Public transportation (reduce reliance on automobiles and promotion of bicycles) ▪ Building energy efficiency (reduce peak electrical energy demand to avoid "dirty" power sources)
Reduced Greenhouse Gas Emissions	▪ Similar to achieving better air quality through urban planning, public transportation and the energy efficiency of the built environment.
Greater Energy Efficiency	▪ Integrated design and economic valuation process ▪ Energy conservation measures ▪ Water conservation (reduced heating and pumping) ▪ Reduced light pollution (more efficient exterior lighting) ▪ Renewable energy and district energy systems
Improved Water Quality	▪ Stormwater management practices (reducing wet weather flows) ▪ Affected by urban forests and wildlife habitats
Improved Water Efficiency	▪ Efficiency improvements to industrial processes (big users) ▪ Selection of efficient fixtures and appliances ▪ Rainwater harvesting (irrigation)
Less Solid Waste	▪ Reduced packaging ▪ Re-use and recycling of materials ▪ Composting of biodegradables (bio-gas)
Protection of Urban Forest and Wildlife Habitat	▪ Urban planning (protection of buffers, habitats and migratory paths) ▪ Better air quality ▪ Improved water quality
Reduced Light Pollution	▪ Integrated design (minimize need for nighttime lighting) ▪ Luminaire efficiency (down lighting) ▪ Controls (switches, timers, occupancy sensors)

Among these measures, the following urban site technologies were identified as being available to the development industry and having the potential to cost-effectively address the environmental drivers forming the basis for the Toronto Green Development Standard. Each urban site technology is followed by the environmental drivers it addresses (in parentheses). Note that energy conservation measures, which address energy efficiency, greenhouse gas emissions, and air quality were dealt with extensively in the preceding section of this report.

Stormwater Management (Improved Water Quality & Water Efficiency, Reduced Urban Heat Island Effect, Protection of Urban Forests and Wildlife Habitats): This represents a host of technologies that include landscape as infrastructure measures, rainwater harvesting and green roofs. Proper stormwater management practices contribute to helping maintain the vitality of urban forests and wildlife habitats. Green roofs, urban forests and wildlife habitats work together to offset the urban heat island effects associated with conventionally paved and roofed surfaces.

Water and Sewage Management (Water Efficiency and Water Quality): The conservation of water is not achieved by the water works technology. Improved efficiencies for processes, fixtures and appliances, as well as rainwater harvesting for irrigation and greywater applications (toilet flushing, car washing, etc.) represent the means of reducing potable water consumption. Reduced water consumption results in lower energy demands for water supply processing, pumping and wastewater treatment.

Solid Waste Management (Less Solid Waste): Construction and demolition waste waste management is an important construction site technology. Post-occupancy, the development can address the last two of the 3Rs (reduce, re-use and recycle) by providing suitable facilities. The composting of biodegradables to produce mulch and bio-gas can displace fertilizers and non-renewable energy.

Renewable Energy and District Energy Systems (Greater Energy Efficiency and Reduced Greenhouse Gas Emissions): Technologies for capturing and generating energy on site within developments help diversify the mix of energy suppliers while improving overall system efficiency and passive survivability (the ability of a building to maintain basic life support during periods when the energy grid goes down.)

Artificial Illumination (Reduced Light Pollution, Protection of Wildlife Habitat, and Greater Energy Efficiency): Nighttime illumination of building interiors, exteriors, parking lots and roadways causes light pollution with documented adverse health effects on humans and wildlife. Thousands of birds are needlessly injured or killed due to inappropriate artificial illumination practices which also waste energy because so much of this illumination is over-powered and ineffective for its intended use.

Beyond the form and fabric of the buildings, these five urban site technologies represent the means by which developers can “build better” and go beyond green buildings to achieve green developments. Each of these is assessed in terms of their cost and benefits, followed by a synopsis on the implementation of appropriate urban site technologies. Unlike the previous section on energy conservation in buildings, however, the costs and benefits will be examined through relevant studies. This approach is necessary because the diversity of urban site technologies and deployment strategies is not manageable at a detailed level within the scope of this study.

Stormwater Management

As part of this study, a comprehensive review of stormwater management strategies for improving water quality and sustaining the vitality of the urban forest and wildlife habitats was undertaken by Professor Pierre Bélanger. A complete report on the costs and benefits associated with various approaches to implementation of this urban site technology is presented in Appendix D of this report.

Stormwater management as it is conventionally practiced in most North American cities is highly questionable in terms of its environmental utility. In virtually all cases, conventional stormwater management techniques accelerate the rate and quantity of runoff which is then discharged into receiving water bodies containing concentrated contaminants. Historically, this aggressive approach to removing stormwater from urban streets involves the automobile. At the time of its inception, automobile technology lacked sealed electrical systems and splashing water could cause cars to stall or breakdown. The response by municipal engineers was to design systems that would rapidly drain water from roadways and parking lots. Standing water, in any form, was viewed as a nuisance that had to be eradicated in the name of progress.[50]

EcoTerrorism Recipe #1
Using polluted rain and melting snow, convey all the dirt, oil, tar, gasoline, cigarette butts, rubber, plastic and metal particulates, dissolved fertilizers, herbicides and pesticides, road salt, and antifreeze, and concentrate this toxic brine in secret underground networks, and then release it directly into streams, rivers and lakes that feed urban water supplies.

LAN2042: Urban Site Technologies 1 – Master of Landscape Architecture Program, 2nd Year Lecture Notes. Professor Ted Kesik, University of Toronto.

The distinction between conventional methods and innovative measures in the management of stormwater flow - a difference that is not explicitly expressed in common literature – is therefore paramount and necessary. These differences stem largely from different purposes and different perceptions. Conventional water engineering as it has been practiced over the past century, treats stormwater as a nuisance or waste, a generic and undifferentiated fluid which needs to be disposed of as quickly as possible, as allowed by regulation. The objective of conventional infrastructure is to temporarily store stormwater, move it offsite and into the local watershed in accordance with the acceptable discharge rate.

Landscape strategies on the other hand, often involving water infiltration technologies and water conservation measures, manage stormwater as a resource, as close to the source as possible. Often referred to as "source controls", these strategies either restore, mimic or improve upon pre-development hydrologic patterns to enable stormwater infiltration into the ground and evapotranspiration into the atmosphere. Using biomass, topography and hydrology, landscape strategies usually entail the design and synergy of several measures by incorporating different technologies throughout a site to considerably decrease and even eliminate the need for conventional detention or retention facilities. As an alternative technique, bioretention for example relies on plans for added efficiency with the multiple functions of retention, infiltration, transpiration and cleansing. Bioretention areas are usually designed as part of a system that incorporates bioswales, permeable surfaces, green roofs, woodlands and other areas to slow, cleanse, infiltrate and evapotranspire stormwater.[51]

As urbanization and especially suburbanization advanced, the adverse effects of conventional approaches to stormwater management on ecological systems became evident. A number of scientists and engineers explored new approaches to managing stormwater in a more sustainable manner. The approaches took on a number of different names, but all were premised on the same strategy: to emulate the natural processes of cleaning stormwater by slowing its rate of overland flow and conveying it through plants, and detaining stormwater so that it could percolate into the soil to hydrate plants and recharge groundwater – simply, to do what it had been doing before the time of urban development and unwitting human interventions.

[50] *Innovative Urban Wet-Weather Flow Management Systems*. James, P. Heaney, Robert Pitt and Richard Field. U.S. Environmental Protection Agency, EPA/600/R-99/029. http://www.epa.gov/ednnrmrl/publications/books/epa600r99029/index.htm
[51] *Urban Stormwater Economics: A Comparative Cost-Benefit Study of Site Technologies & Strategies for the City of Toronto*. Pierre Bélanger, University of Toronto, 2008.

The importance of appropriate stormwater management practices to the green development agenda is among the highest of all environmental drivers. Sustainable stormwater management offers the following benefits:

- Water balances between land and water features are maintained at historical (pre-development) levels to restore and preserve native ecology;
- Receiving water bodies are not contaminated by urban runoff, thus contributing to improved quality of water and aquatic habitat;
- Urban forests and wildlife habitats are preserved so as to contribute to improved air quality, reduced urban heat island effect and biodiversity; and
- Reduced runoff reduces stormwater treatment costs, solid waste, energy consumption and greenhouse gas emissions.

Stormwater management, also known as wet weather flow management, is the key to sustaining Toronto as a livable city. Without it, there would be no vital waterways, ravines and trees to cleanse and replenish the water in Lake Ontario. It is arguably the most critical environmental driver behind the Toronto Green Development Standard.

The City of Toronto has recently come to this very realization, and over a period of several years, it has developed the *City of Toronto Wet Weather Management Plan*. The plan has spawned practical guidelines and an implementation report to assist in the transition from conventional stormwater management practices to what are sometimes referred to as "*low impact development*" or "*best management practices*" and more recently "*landscape as infrastructure*" – a term coined at the University of Toronto that explicitly recognizes the original role of the natural environment in providing humanity with all of its infrastructure needs. Regardless of the terminology, it has been recognized that the transition to these more ecologically informed practices will encounter resistance - not due to any fundamental dispute over the effectiveness or reliability of Nature's housekeeping abilities, but simply in response to unfamiliarity. This inherent trait of innovation and technology transfer is recognized within the implementation report:

The Wet Weather Flow Management Guidelines[52] *were completed in November 2006 after consultation with staff and the Toronto Region Conservation Authority. While the Guidelines present a general framework of the City's expectations of approval requirements on water balance, water quality and quantity targets for on-site stormwater management, the City also recognizes that flexibility is important for certain site-specific conditions. As a result, the City may consider any innovative approach if it can be demonstrated that there are better ways of achieving the same performance objectives.*

The Wet Weather Flow Management Guidelines is a "living" document; therefore, it is anticipated that there will be technical refinements and updates over time. There is also consideration to introduce by-laws to enforce the guidelines, however, any initiative of this kind will involve public and stakeholder consultation and review before it is presented to City Council for approval.[53]

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[52] *Wet Weather Flow Management Guidelines*. City of Toronto Water Infrastructure Mnagement, November 2006.
http://www.toronto.ca/water/protecting_quality/wwfmmp/pdf/wwfm_guidelines_2006-11.pdf

[53] Wet Weather Flow Master Plan: Implementation Report 2006. City of Toronto Water, October 2007.
http://www.toronto.ca/water/protecting_quality/wwfmmp/pdf/implementation-report-2006.pdf

Costs and Benefits

The research conducted by Bélanger compares costs and benefits between conventional approaches and those employing landscape as infrastructure. The results are overwhelmingly in favour of the latter approach. The full report provides detailed assessments, however, the highlights have been summarized below:

- Improved water quality and the restoration of pre-development hydrological conditions are only possible through stormwater management techniques that involve intelligent, ecological interventions. There is no substitute for managing water resources in an environmentally sustainable manner.
- For developers and municipalities, it is significantly more cost effective to employ landscape as infrastructure strategies, both initially and over the life cycle of the development. Savings can range anywhere from approximately 5% to 20% initially, with downstream savings varying widely depending on the environmental impacts of stormwater drainage through municipal systems. As an example, where combined sewer overflow is caused by system effects, the savings include cost of treatment, impacts on wildlife, closure of beaches, etc.
- Green roofs are a notable exception where their initial cost is higher (now rapidly decreasing) but the life cycle costs are much lower. Green roofs should be viewed as a stormwater management infrastructure investment that is shared between municipalities and developers/owners to provide multiple benefits in terms of urban heat island effect mitigation, improved air quality and habitat preservation.
- Landscape as infrastructure approaches reduce the land area devoted to stormwater management and enhance property values, while promoting more healthy urban forests and wildlife habitats.
- Additional economic benefits include higher property values, increased tourism and recreation, increased tax revenue and reduced needs for infrastructure project bonding.
- Intangible benefits are related primarily to the contribution by the urban forest and natural landscapes (wildlife habitats) to improving air quality and mitigating urban heat island effects. These benefits can be translated into economic benefits, but air quality and comfort are aesthetic experiences of the outdoors that carry their own intrinsic value.

The case studies cited indicate at least a 25% to 30% overall reduction in costs associated with site development, stormwater fees, and maintenance for residential developments that use landscape infrastructure techniques. These savings are achieved by reductions in clearing, grading, pipes, ponds, inlets, curbs and paving. Far outweighing any of the initial design cost increases that may be incurred, the associated infrastructure reduction savings enable developers to add value-enhancing features to the property, to be more flexible and competitive in pricing their products, or even to recover more developable space since there is no need to waste land for conventional stormwater management measures. Sufficient savings may even be realized to fund investments in other site technologies to improve the cost competitiveness and sustainability of new developments. This entire systems approach to green development will be explored later in this report. It is important to note that the preceding discussion focuses on greenfield developments – densely built up urban areas require different and innovative approaches that are only now emerging.

More recently, for example, a single heavy storm event in August 2005 resulted in the washout of a major arterial road, damaging three other roads, and a wastewater plant downstream. This single rain event cost the City of Toronto an estimated $34 million, including $6 million for the immediate repair of Finch Avenue, $9 million for surrounding parks, and over 1,600 over-time staff hours. The environmental clean up cost to mitigate the effects of a broken sewer main that ruptured during the storm, (releasing raw sewage into a nearby stream at 7 cubic meters per second), may incur additional costs. The Insurance Bureau of Canada estimates over $400 million was paid out to private citizens to cover flood damage to basements from this storm. All told, the cost of damage from this single rain event was astronomical. By pushing the stormwater system past its capacity these events will only become more common.

Urban Stormwater Economics: A Comparative Cost-Benefit Study of Site Technologies & Strategies for the City of Toronto. Pierre Bélanger, University of Toronto, 2008.

The North American experience with conventional approaches to stormwater management marks over a century of escalating environmental degradation. Ecologically sustainable alternatives are being rediscovered, aided by our improved understanding of urban hydrology and environmental engineering principles. Landscape infrastructure approaches hold enormous potential to rehabilitate existing urban settlements and sustainably service new developments.

Perhaps the most significant theme gleaned from the literature is that, by combining multiple technologies, such as clustering and permeable surfaces, bio-swales, and other practices, deeper cost savings can be achieved from the resulting opportunities to downsize the infrastructure. This fact suggests that a dualized approach to the design of infrastructure - where techniques are designed together yielding multiple functions that can be doubled within a single system - the individual benefits of specific tools cannot be separated from the overall benefits of a complete site design, whereby the cumulative economic benefits of the site design can be impressive. Across the case studies examined here, landscape strategies and water conservation practices saved an average of 36% over conventional practices.

Furthermore, research suggests that the design of stormwater infrastructure can and should be combined with other systems, such as pedestrian and cycling infrastructure and open space networks. From an economic, ecological and spatial perspective, the combination of linear systems such as bio-swales adjacent to pedestrian walkways or bicycle lanes, or the combination of infiltration trenches with roadway medians, are feasible alternatives to conventional, specialized forms of engineering and planning. Overall, this synthetic approach suggests a dualization of public infrastructure - where economic, ecological and spatial goals are combined – melding the objectives of stormwater management with the challenge of mass transportation systems, and metropolitan open space networks by design.

*Finally, it is important to remember that the synthesis of stormwater management infrastructures using urban landscape strategies is of global importance. With over 60% of the world's population living in cities according to the United Nations by 2020, the reclamation of stormwater as a resource is - despite its invisibility - critically important to the future of urban areas given that over 30% of the world's freshwater supply is contained in the ground. (*Bélanger, 2008.)

In relation the Toronto Green Development Standard, this study concludes that requirements for water quality (stormwater management) can be achieved cost effectively with no financial burden to developers, consumers and municipalities. All indications point to lowering initial and lifecycle costs while providing measures for improving water quality exhibiting a higher effectiveness. But to realize these savings and benefits, integrated design, collaboration between design disciplines and cooperation between developers and municipalities is essential. The City of Toronto has and is actively reviewing and revising many of its requirements and standards as they apply to municipal infrastructure, so that infrastructure delivers more sustainable performance. The Toronto Green Development Standard should be viewed as providing a timely vehicle for the effective deployment of innovative urban site technologies.

Water and Sewage

Water is essential to human survival; with concerns over its future quantity and quality becoming more critical to the global community, Canadians must become more effective in conserving and protecting precious water resources. The City of Toronto has an aging water, wastewater and stormwater infrastructure that is continually put under stress by increased consumption, development and population growth. Without the implementation of conservation measures, increased demand necessitates investment in new water treatment, wastewater treatment and stormwater management capacity. Since 1993, water conservation has been a documented priority for the City with the introduction of reduction targets, which have been frequently updated to meet the changing needs of both regulators and citizens, keeping in mind the needs of future generations.

"Canadians are always told by our politicians and media that we have abundant supplies of fresh water from our lakes and rivers. But the statistics do not bear this out. The true measure of water that we can use sustainably is the annual runoff from land. If we exceed that value, our water use is unsustainable. Canada has seven percent of the world's land mass, and produces seven percent of the world's terrestrial runoff. In other words, we have just an average supply of sustainable freshwater by global standards. Another common myth is that we have more water than the USA. Again, the numbers dispel the myth. The runoff per unit area in the two countries is almost identical.
One reason for the apparent abundance of our freshwaters is that we have abundant places for water to collect—in the depressions left by receding glaciers several thousand years ago. But having more basins to catch rain does not mean that more rain falls! Much of northern Canada, where freshwater is most abundant, receives less than 250 millimetres of precipitation per year. Many of the larger lakes would require 100 years or more to refill if we emptied them."

David Schindler, Killiam Memorial Chair and Professor of Ecology, University of Alberta.

From the perspective of the Toronto Green Development Standard, requirements for water conservation imply costs to all stakeholders. These costs are unavoidable as fresh water supply and sewage treatment are essential services in urban settlements. The issue is how to minimize these costs while reinforcing behaviour that conserves finite water resources. The present situation for municipal waterworks and potential for conservation will be examined next to provide a context for this urban site technology.

Water Consumption in Canada

In 2001, the average Canadian daily domestic use of fresh water per capita was 335 litres. This rate is second only to the US, and more than double the amount used by most Europeans. This is not necessary. Of the cities surveyed in Canada, Charlottetown used the least amount of water residentially, at 156 litres per capita per day, while St. John's, at 659 litres, used the most. Victoria and Vancouver were close to the national average, using 340 and 357 litres per-capita, respectively [similar to Toronto].

Although Canada has a significant amount of fresh water, we possess only 7% of the world's *renewable* freshwater supply. In Canada, 84% of the population lives in a narrow southern band, while 60% of our water supply flows north to the Arctic Circle. Our growing population, and our growing thirst for water, are being concentrated in expanding metropolitan areas, and are forcing water regulators and policy makers to find ways to stretch available supplies even further. Increasing pollution of surface and groundwater is further reducing the supplies of readily available, clean water. Because our water use almost always leads to some degree of deterioration in water quality, the less water we withdraw, the less we upset the natural balance of our aquatic ecosystems. And, the less we upset the ecosystem, the less we have to spend to restore the water quality to an acceptable standard for public use. Finally, financing by municipal governments for the treatment of water supplies and wastewater is becoming increasingly constrained.

[Source: Environment Canada. http://www.ec.gc.ca/water/en/info/pubs/FS/e_FSA6.htm]

It is important to note that virtually all of the potable water delivered by the municipal water works returns for sewage treatment. Conserving water also reduces the amount of sewage treatment required – less effluent and less energy. In the case of hot water conservation, achieved by means such as low consumption fixtures and appliances, reductions in energy used to heat the water are also realized. The pumping of water in municipalities represents a significant component of annual operating costs that is also reduced when water is conserved.

Water use in the residential sector accounts for about 52 per cent of all the water supplied in the City of Toronto. This is also known as the average winter day demand. About 248 litres of water per person per day is used inside the home. See the graph below for a breakdown of indoor water use that reflects typical residential consumption in North America.

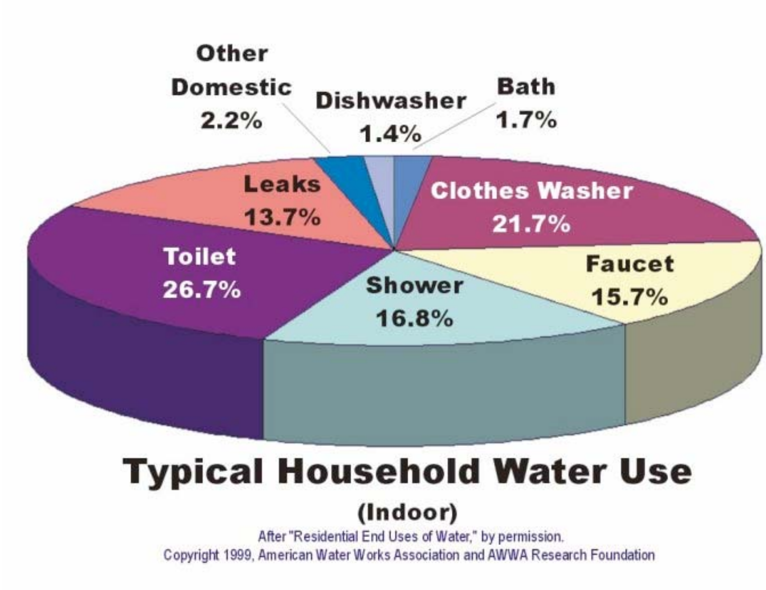


Figure 18. Breakdown of water consumption by end-use in North America.

The average winter day demand is not the same as total per capita consumption. Per capita consumption is about 510 litres per person per day. This number takes the total water supplied and divides it by the total population of Toronto. Per capita consumption incorporates all sectors in the city: residential, commercial, industrial and institutional. In summer, the demand for water increases by as much as 80 per cent compared to the amount of water used in the winter, due to water consumed to water lawns and gardens, wash cars, fill and backwash pools, irrigate municipal parks and industrial landscapes and to cool large commercial buildings.

[Source: City of Toronto Water Efficiency. http://www.toronto.ca/watereff/home.htm]

Conservation Strategies

The most commonly referenced water conservation measures found across a wide range of Canadian programs include:

- Progressive plumbing codes and regulations;
- Water efficient appliances and fixtures;
- Domestic grey water recycling;
- Water efficient landscaping;
- Water pricing policies; and
- Reduced distribution losses.

It is important to note that non-residential uses are roughly as significant as residential water consumption, and new development accounts for only a small fraction of all buildings in most communities. Hence the contribution of water conservation in new developments to the sustainability of municipal waterworks represents one facet of a comprehensive societal program.

As an example, the City of Winnipeg has reported, "*The prevailing per capita residential water demand growth rate will not be as high as in the past due to demographic and technological changes. Technology change in residential water use is inevitable specifically with respect to implementing lower water-use toilets and showerheads. These changes could reduce per capita demand projections by up to 25%. In Winnipeg, the population is expected to grow at about the same rate as the per capita water demand will decline, therefore the total water demand projection is essentially constant*."

[Source: http://www.winnipeg.ca/waterandwaste/water/waterfront/evaluation.htm]

In terms of voluntary water conservation strategies in new housing, the three most promising approaches available to builders are water efficient appliances and fixtures, domestic grey water recycling, and water efficient landscaping (this last option is interchangeable with rainwater harvesting coupled to drip irrigation systems for conventional landscapes). These strategies are also applicable to other types of developments, however, water efficient fixtures, appliances and equipment often deliver the biggest reductions in consumption.

The reductions available due to the use of water efficient appliances and fixtures depend on the plumbing codes in a particular jurisdiction, as these establish the minimum efficiency thresholds. The actual reductions in consumption attained cannot be simply calculated by comparing water consumption between typical and water efficient appliances and fixtures. For a comprehensive database of case studies, refer to Canadian Water and Wastewater Association (CWWA), Water Efficiency Experiences Database (WEED) at http://www.cwwa.ca/WEED/Index_e.asp.

A study conducted on behalf of the town of Oliver, British Columbia to examine the potential for water conservation through residential measures estimated a reduction of 59% indoors, and 66% outdoors. Public education accounted for about one-sixth of the estimated reduction, indicating that technological innovations must be coupled to appropriate behaviour to attain full benefits.

[Source: Smart Growth on the Ground, Foundation Research Bulletin: Greater Oliver. Design Centre for Sustainability at UBC and Oliver Brandes, April 2006. http://www.sgog.bc.ca/uplo/OlFRB_WaterConservation.pdf]

In the absence of progressive plumbing codes and regulations, full cost water pricing structures, and widespread public education programs, the development industry is facing the same problem with water conservation as it has with energy conservation. One possible approach is to develop a nationally recognizable label for water efficient products. Modeled after a successful precedent, such as the voluntary Energy Star labeling program, a water efficiency label would help protect the environment by enabling purchasers to identify and select the most water efficient products that meet their needs. Manufacturer participation would be entirely voluntary. Products would earn the right to use the water efficiency label by meeting specific efficiency criteria set by Environment Canada in consultation with industry.

Another option is to embed water conservation measures within an energy labeling program so that it effectively becomes an integrated performance rating label that considers factors such as energy efficiency, water consumption and ecological footprint. Regardless of the approach, there is a need to conserve water in Canada and CHMC has published a number of case studies indicating that residential water consumption can be reduced by approximately 50% with no appreciable impact on quality of life [http://www.cmhc-schl.gc.ca/en/inpr/su/waco/index.cfm].

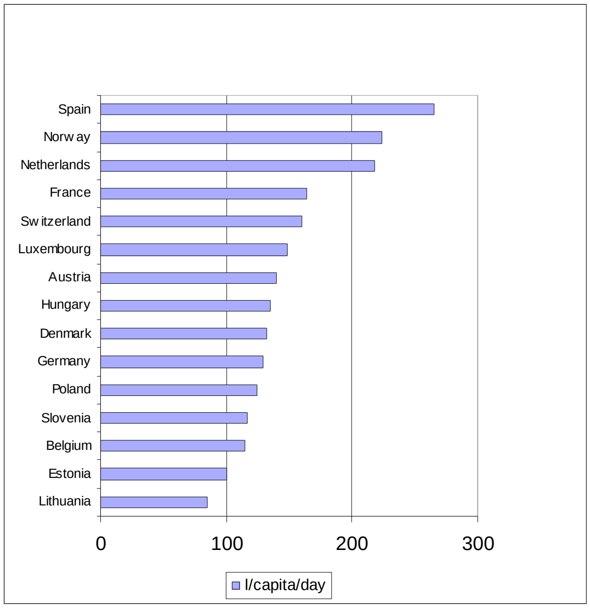


Figure 19. Average daily per capita domestic water consumption in Europe averages 150 litres per day compared to 335 litres per day in Canada.

[Source: European Water Association (EWA), Yearbook 2002.]

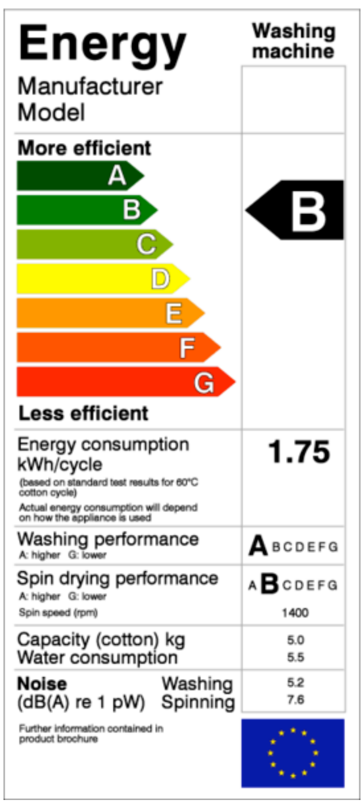
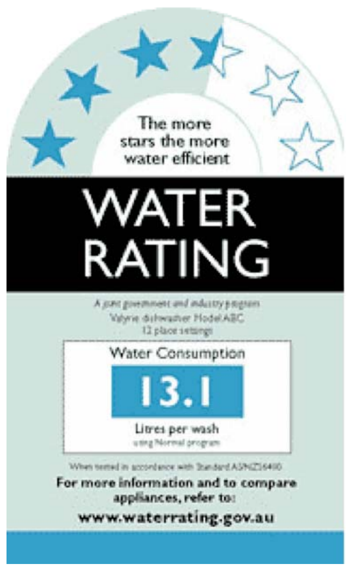


Figure 20. Typical European energy rating label for a water consuming appliance provides both energy and water consumption data, along with a performance rating.

The WELS standard that sets out the criteria for rating the water efficiency and/or performance of each WELS product type is the Australian and New Zealand Standard *AS/NZS6400:2005 Water-efficient products—Rating and labelling*. This standard is the basis for the star ratings and water consumption and flow displayed on the WELS label.

[Source: Water Efficiency Labeling Scheme http://www.waterrating.gov.au/about/index.html]



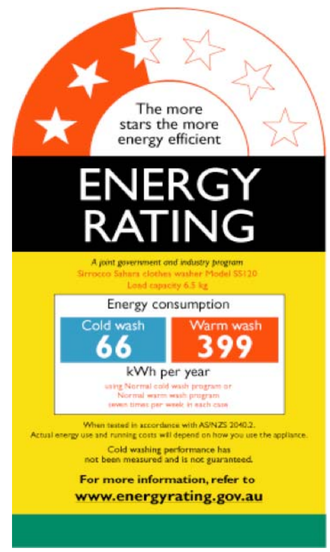


Figure 21. Australia's WELS rating label is attached along with the energy rating label to water consuming appliances so that consumers are aware of both the water and energy efficiency characteristics.

In comparison to the European and Australian responses, it appears the acceptance of the need for water efficiency continues to lag in North America. This reality is reflected in the highlights from a recent research report published by California's Pacific Institute:

- *A water-efficient future for California is possible.*
- *The Pacific Institute High Efficiency scenario shows that water use in 2030 could be 20 percent below 2000 levels, even with a growing population and a healthy economy.*
- *A water-efficient future is achievable, with no new inventions or serious hardships.*
- *Implementing serious efficiency improvements requires actions on the part of legislators, water managers, water districts and agencies, farmers, corporations, and all individuals.*
- *The sooner such actions are taken, the easier the transition to an efficient future will be.*

[Source: *California Water 2030: An Efficient Future*. Peter H. Gleick, Heather Cooley, David Groves, Pacific Institute, Oakland, California, September 2005. http://www.pacinst.org/reports/california_water_2030/ca_water_2030.pdf]

Efforts are currently under way at the U.S. Environmental Protection Agency to develop a water efficiency labeling program for water consuming fixtures and appliances. Numerous organizations, such as the American Water Works Association, provide public outreach programs and resources for effective municipal water management and conservation programs. Despite these efforts and resources, water consumption in North America continues to increase.

Water Conservation – City of Toronto

In 1993, Metro Council adopted a water reduction target of 15% by 2011 to reduce the need for capital expenditures in both water and wastewater. By December 2002, the City of Toronto published its Water Efficiency Plan (WEP) outlining programs and measures to be implemented within a ten year period to meet consumption demand. The 2011 demand was estimated using population estimates and a "business as usual" water consumption, revealing that peak demand would reach 2,183 million litres/day (ML/day) if an efficiency plan were not implemented. The WEP, as laid out in 2002, was estimated to cost $74 million and save an estimated $220 million dollars in expansion fees, due to a reduction in peak demand by 266 ML/day.[54] This may be compared to the average annual daily demand (AADD) savings in Figure 22.

The WEP contained comprehensive programs through incentives for various sectors including ICI, multi-unit residential and the single-family dwelling. At the top of the list was the toilet replacement program, which would require the replacement of over 700,000 with a savings of approximately 100 ML/day. This program represents 57% of the $74 million dollar budget, is currently in full swing as a priority within the WEP[55]. The washing machine replacement program is another high priority for the WEP in the single-family and multi-unit residential sectors. The results of a 1999 Pilot Study demonstrated that laundry water use was reduced, on average, by 46% and the cost of heating water for laundry was reduced by 63%.

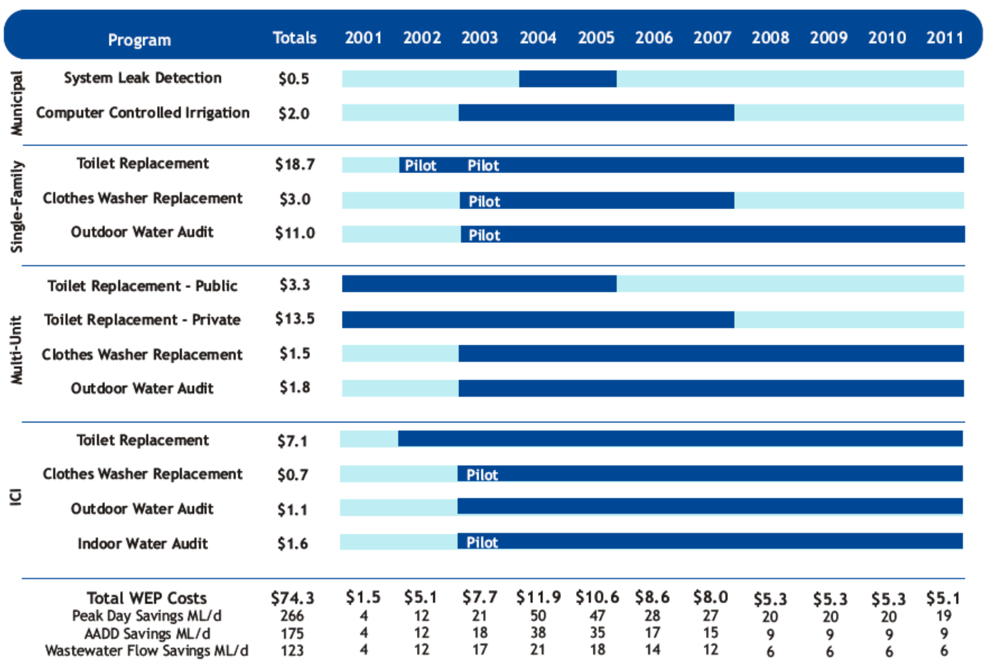


Figure 22. Water Efficiency Plan – implementation schedule.
[Source: *Water Efficiency Plan*. City of Toronto, Works & Emergency Services, December 2002. p. 22.]

[54] Water Efficiency Plan. City of Toronto, Works & Emergency Services, December 2002. p. 17. However, in Toronto Water's Multi-Year Business Plan (Toronto Water, 2005) the WEP is said to reduce capital budget requirements by $146 million and operating budget by $29 million over 10 years.
[55] 2007 Budget Briefing Note - Updating the Water Efficiency Rate. Toronto Water, January 5, 2007. p.1.

The City has been tracking the success of the WEP, as part of the Toronto Water Annual Reports summarizing annual program uptake and water consumption rates. Based on the 2006 annual report[56], uptake rates of some measures were noted to be lower than projected; a participation survey was conducted in 2007 to study this phenomenon and assist in program development.

Toronto Waterworks Budgets, Price Structures and Projections

The following table summarizes 2007 expenditures by Toronto Water in the area of drinking water treatment and supply:

Budget Line	Water Treatment and Supply
Operating	$110,773,000
Capital	$132,698,000
Total	**$243,471,000**

Table 19. Toronto Water – operating and capital spending in 2007.
[Source: Toronto Water]

As of January 1, 2008, the City of Toronto has moved from a seven block water rate structure to a single rate system with a lower block rate for industrial users on consumption over and above 6,000 m^3.

According to Toronto Water, a rate increase of 9% per year is expected for the next 5 years to accommodate Water Efficiency Plan conservation measures and planning for 2031 demand.

Table 20. City of Toronto 2008 metric water rates.		
General Water Rate		
Applied to ALL water consumption, including the first 6,000 m^3 of industrial consumption.		
Rate if paid, after Due Date	**$1.8265 / m^3**	**$0.00830341 / gal**
Rate if paid, on or before Due Date	**$1.7352 / m^3**	**$0.00788835 / gal**
Industrial Water Rate		
Applied to water consumption over 6,000 m^3 for those businesses classified under the Industrial Tax Class		
Rate if paid, after Due Date	**$1.4612 / m^3**	**$0.00664272 / gal**
Rate if paid, on or before Due Date	**$1.3881 / m^3**	**$0.00631041/ gal**
Canadian municipal rates posted at: http://www.ec.gc.ca/Water/en/manage/use/e_mun.htm		

[56] As reported in 2007 Budget Briefing Note - Updating the Water Efficiency Rate. Toronto Water, January 5, 2007. p.2.

Table 21. International water rates* - $Cdn per m^3.

Location	$Cdn/m^3
Germany	2.48
United Kingdom	2.11
Belgium	1.91
France	1.74
Netherlands	1.65
City of Toronto	1.60
Italy	1.27
Finland	1.14
Australia	1.11
Sweden	0.95
Canada	0.87
United States	0.73

* The survey is based on prices as of July 1, 2006 for an organization with an annual usage of 10,000 cubic metres.
Source: NUS Consulting Group, 2005-2006 International Water Report
http://www.2ontario.com/welcome/oout_600.asp

Toronto Water has projected future water demands based on population analysis and developed in association with the City of Toronto Official Plan. The Flashforward population tables, developed in 2002, predict a Toronto population only slightly lower than the predictions in the Places to Grow Reference Scenario:

Year	Places to Grow	Flashforward
2001	2,590,000	2,471,355
2011	2,760,000	2,742,345
2021	2,930,000	2,822,569
2031	3,080,000	2,905,426

Table 22. Toronto population forecasts.
[Sources: ***Places to Grow - Growth Plan for the Greater Golden Horseshoe.*** Ministry of Public Infrastructure Renewal, 2006. Schedule 3.; *Flashforward: Projecting Population and Employment to 2031 in a Mature Urban Area.* Urban Development Services, June 2002.]

Toronto Water indicates that the currently available sustainable supply of water to the City is 1762 ML/day, while current demand is 1728 ML/day. Water demand in 2031 is projected to be 1956 ML/day, and will be met with a capacity of 1963 ML/day, made available through system expansion and agreements in place with the Region of York. This prediction is only marginally higher than predictions for 2011 demand made in the early days of the WEP development (a 2% increase over 2011 prediction, with a 6% population increase). It remains to be seen if the projected growth up to 2031 can be accommodated within the current system expansion plans, or if even greater investments in waterworks infrastructure will be necessary to support growth.

The traditional response to gaps between water supply and demand is to increase supply. Beginning from Roman times, we have brought water to cities and fields by building larger dams, drilling more deeply, and extending pipelines further. However, costs to develop new water supplies are doubling every decade. And increasingly, as in the Great Lakes basin, the need to avoid or mitigate social and environmental impacts is adding to those costs – and in some cases halting supply projects altogether. The problem is not with the engineering but with the goals of the entrenched supply-side approach, which relies on ever greater, ever more distant sources of supply.

The alternative to conventional supply-side management is demand management. The scope for cutting water use by managing demand is huge, particularly in Canada and the United States, which have been egregiously wasteful in their use of fresh water. That scope depends upon two forces: water efficiency and water conservation. Though overlapping in both cause and effect (each is, for example, promoted by higher prices for water), the two are conceptually distinct. "Efficiency" refers to technical and economic approaches to reducing the quantity of water used to achieve a given task, as with watering lawns with low-flow sprinklers; "conservation" refers to changes in the nature of the task, as with planting greenery that does not require watering.

Determining the potential for water-use efficiency is time-consuming but can be accomplished through sector-by-sector and use-by-use measurements that do not strain known methodologies. A large literature is already available on water-saving technologies together with estimates of their cost-effectiveness for various degrees of water saving. Determining the potential for water conservation is more difficult. Conservation includes some relatively easy changes in individual habits and practices, such as replacing lawns with drought-tolerant ground cover, or using grey water for outdoor use around buildings and homes. However, conservation also includes more complex communal decision-making concerning urban design and industrial planning to reduce the impact of suburbanization and limit the growth of such water-intensive industries as aquaculture, aggregate mining, and irrigated agriculture. Conservation therefore has much broader social and economic impacts than efficiency, and is even more powerful in achieving significant, lasting water use reductions.
[Source: Friends of the Earth, Submission to Council of Great Lakes Governors, September 2004.
http://www.waterdsm.org/pdf/Annex_Comments_brooks_maas.pdf]

Water efficiency and water conservation are highly cost effective investments for all stakeholders, especially when compared with the inevitable alternative. The previous section on stormwater management demonstrated that landscape infrastructure can retain runoff and reduce water demand cost effectively. It also positively impacts water quality and therefore reduces treatment costs. Prior to that, water conservation in MURBs was demonstrated to be cost effective based on energy savings alone. The cost difference between water efficient and conventional plumbing fixtures, appliances and equipment is negligible, but the difference in water efficiency is significant. In the context of the Toronto Green Development Standard, it may be concluded that water efficiency and conservation are preferable to higher costs for water and the expansion of municipal waterworks infrastructure. However, there are aspects of this urban site technology which go beyond the control of developers and municipalities, and reside with citizens. Changes in societal values for water and attitudes toward water use are key to green development in the Great Lakes region. The Toronto Green Development Standard can effect the 'hardware' needed in new developments, but the social 'software' will require major editing before sustainable water and sewage systems are achieved.

Solid Waste Management

Similar to stormwater management, solid waste management is an urban site technology that exerts environmental impacts while economically affecting developers, consumers and governments (society). Unlike stormwater management, solid waste has little potential for becoming cost effective, rather it is a cost that can only be minimized along with impacts such as environmental degradation and resource depletion.

Under the January 2007 version of the Toronto Green Development Standard, requirements for solid waste management are confined to the construction process. Requirements for the provision of facilities that promote recycling and composting in new developments, especially multi-unit residential buildings (MURBS) remain to be developed. This section of the study reviews both construction and demolition (C&D) waste and post-occupancy waste streams.

Figure 23. Relegating garbage to landfills is one of the most visible among a host of controversial issues surrounding the solid waste management debate. (Photo: Matthew Blackett)

General information and statistics on solid waste management from the City of Toronto's web site is excerpted below:

From January to August 2007, on average, 74 truck loads per day of solid waste (approximately 441,363 tonnes) went to Michigan landfill…down from 142 daily truck loads in 2003. This includes waste the City collects from residents, ICI (Industrial, Commercial, Institutional), ABC&Ds (Agency, Boards, Commissions, Divisions) and schools.

Toronto sent approximately 696,327 tonnes of waste to Michigan landfill in 2006. Toronto's waste disposal contract with the Carlton Farms Landfill in Michigan expires at the end of 2010. Effective April 2, 2007, the City of Toronto became official owners of the Green Lane Landfill Site located in Southwold Township in the County of Elgin, southwest of the City of London, about 200 km from downtown Toronto. The Site features the latest technology including onsite treatment of leachate and a methane gas collection and flaring systems. As of mid-April 2007 through to the end of August 2007, Toronto sent on average, three loads per day of solid waste to Green Lane Landfill, an amount equal to approximately 11,735 tonnes.

Solid Waste Management Services has the following facilities:

- *seven Transfer Stations*
- *one Organic Processing Facility*
- *six HHW depots (Household Hazardous Waste)*
- *two MRFs (Material Recovery Facility for sorting recyclables)*
- *three Maintenance Yards*
- *one Landfill (Green Lane Landfill Site)*

Current Waste Diversion Statistics

In 2006, 42% of Toronto's residential waste was diverted thanks to the Blue/Grey box, Green Bin and Yard Waste composting programs. This means 375,621 tonnes of garbage were kept off Michigan trucks. In 2006, multi-unit dwellings (apartments and condos) recycled only 13% of their garbage. The City, looking to improve that statistic, is launching a new volume-based rate structure in 2008 to enhance recycling rates. The results from piloting various waste diversion programs in select multi-unit buildings will be used to implement new programs.

In 2007, Toronto City Council approved the "Getting to 70% waste diversion from landfill plan", which lays out the plan to increase waste diversion to 70% by 2010 and the funding model by which this goal can be achieved. By achieving 70% diversion, Solid Waste will reduce its GHG (greenhouse gas) emissions by an additional 25 per cent, which is equal to taking over 100,000 cars off the road. With 70% diversion, Toronto will recycle 240,000 tonnes of paper annually, to save 4.5 million trees a year. Diverting 70% of its waste means Toronto will recycle enough Blue Box materials to save 900 million kWh (kilowatt hours) of energy annually, which is enough to supply all the electrical needs for 170,000 homes.

The Green Bin Program, which collects and processes household organic waste so it can be turned into finished compost, is now available to all 510,000 single-family households across Toronto. With city-wide single-family household participation, approximately 100,000 tonnes of waste is diverted from landfill annually (resulting in 2,750 fewer trucks to Michigan each year). In 2006, Toronto recycled 163,385 tonnes of residential blue/grey box recyclables (resulting in 4,805 fewer trucks to Michigan).
[Source: *Facts About Toronto's Trash*. Updated November 2007. http://www.toronto.ca/garbage/facts.htm]

Construction and Demolition (C&D) Waste

Statistics for the GTA on construction and demolition waste, sometimes also referred to as construction, renovation and demolition (CRD) waste, are sparse and incomplete. It was not possible to obtain a reliable estimate of the fraction of Toronto's solid waste that is comprised of C&D waste. Past studies and comparisons with other jurisdictions indicate anywhere from 30 – 40 % of municipal solid waste comes from the construction industry. General research on C&D waste in the context of the GTA yielded two sources of information:

Each year, the Greater Toronto Area (GTA) generates about seven million tonnes of industrial, commercial, institutional and C&D waste. This is transported from the GTA and other parts of Southern Ontario to landfills located in U.S. border states on long-haul trucks, which collectively emit high levels of CO_2, cause serious wear-and-tear on the province's highways and congest Canada-U.S. border crossings.
[Source: First Waste Transload Inc., March 2008.
http://www.marketwire.com/mw/release.do?id=833639]

The volume of C&D waste is not as large as in other sectors. While 1.2 million tonnes of C&D waste were generated in 2002, the residential sector generated 4.4 million tonnes, and the industrial, commercial, and institutional (IC&I) sectors generated 6.5 million tonnes. However, the C&D recycling rate is the lowest of the three sectors (Ministry of Industry Canada, 2004). C&D wastes consist mainly of concrete, asphalt, metals, wood, and gypsum. These materials are currently being recovered and processed into recycled content products (Recycling Council of Ontario, 2005). Concrete and asphalt, in particular, are highly reused, but others are not recycled effectively. Even the recycling rate of concrete and asphalt are not high, compared to the Japanese recycling rates which are more than 98 percent (Ministry of Land, Infrastructure and Transport Japan, 2006). The differences in the recycling rates can be explained by the difficulties of the recycling process and the demand for recycled materials from industry.
[Source: *Development of Construction and Demolition Waste Recycling in Ontario*. Tomo Saotome, McMaster University, August 2007.
http://msep.mcmaster.ca/publications/Development_of_C&D_recycling_in_Ontario.pdf]

Figure 24. Construction waste management practices range from none (left image) to properly managed recycling facilities (centre and right images).
[Source: http://www.wbdg.org/resources/cwmgmt.php]

Much of the problem with C&D waste is apparently due to a lack of appropriate government regulations and consistent enforcement.

Although the Province of Ontario has existing regulations to control the generation, handling and transportation of CRD wastes (103/94), it has only chosen to actively regulate handling and transportation, while those regulations designed to minimize CRD wastes and maximize reduction and recovery have rarely, if ever, been communicated, let alone actively enforced.
Appendix 6: Demolition and Construction Waste. Dillon Consulting Limited, October 2004. Regent Park Redevelopment Project Sustainable Community Design Final Report.
http://www.regentpark.ca/pdfs/revitalization/sus_appendix6.pdf

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The McMaster study pointed out that without a mandatory minimum content for locally re-used and/or recycled materials, there is no stable and dependable market for construction and demolition waste. In addition, the following issues need to be addressed:

- Review of the provincial 3Rs regulations, extending their scope to include all types and scales of CRD activities, especially demolition;
- Mandatory reporting of all CRD waste generated (waste auditing and waste reduction plans, accompanied by disposal receipts);
- Landfill taxes used as a means of promoting re-use and recycling;
- Education of the construction industry and enforcement officials; and
- Industry's environmental consciousness regarding 3Rs is extremely low and needs improvement – proper training on procedures is critical.

The largest cost associated with the appropriate management of C&D waste is due to supervising worker behaviour to ensure separation of waste streams on site. Source separation is the key to reducing costs. Proper planning for waste bins and ensuring there are sufficient bins available is the next biggest challenge, however, experienced and knowledgeable contractors admit this is no more difficult than coordinating logistics associated with any other aspect of a construction or demolition project.

The recently published waste diversion strategy for York Region, to the north-east of Toronto, predicts a maximum diversion potential for C&D waste of 2.5%.[57] The nature of the new development taking place in York Region is not unlike Toronto and the Greater Golden Horseshoe, holding in common many of the industry players. The diversion target in the Toronto Green Development Standard is set at a minimum of 50% and in view of the York Region forecast, will likely require some degree of enforcement or incentive to realize C&D waste diversion requirements.

Solid Waste (Garbage)

Following the construction process, occupied developments require solid waste management services. This is an area that is not currently addressed within the Toronto Green Development Standard, however, it has far greater life cycle cost implications than the construction waste for most typical projects. Promoting the separation of waste streams is the key to success in waste management programs. Facilities should make recycling, composting and garbage separation, storage and transfer/pick-up convenient. This promotes the City of Toronto's goal of waste diversion.

With the mandatory 2002 closure of the Keele Valley landfill then on the horizon, City Council signed a disposal contract with a private landfill in Michigan in 2000. This was not part of a long-term plan, but was a temporary stopgap measure to allow for the development of more sustainable alternatives. The Waste Diversion Task Force 2010, established in 2001, was tasked with the responsibility of developing a plan by which 100 percent of Toronto's waste would be diverted from landfill by 2010. The Plan that emerged included intermediate targets of 30% diversion by 2003 and 60% by 2006; the 2003 target was exceeded (32% reduction was reached), while the 2006 target was not met (only 42% diversion was reached).

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[57] *Joint Waste Diversion Strategy*. York Region, September 2006.
http://www.york.ca/NR/rdonlyres/elyyc72v2aedbtzpu3wa4ivt5bb3mfpdjr3x5mkgwz7ust43u3dliyi52qbv72bqfc7np4u5gollcsugro465i6gih/YORK-%23320930-v2-Waste_diversion_strategy_final_version_Sept_2006_doc+%282%29.pdf

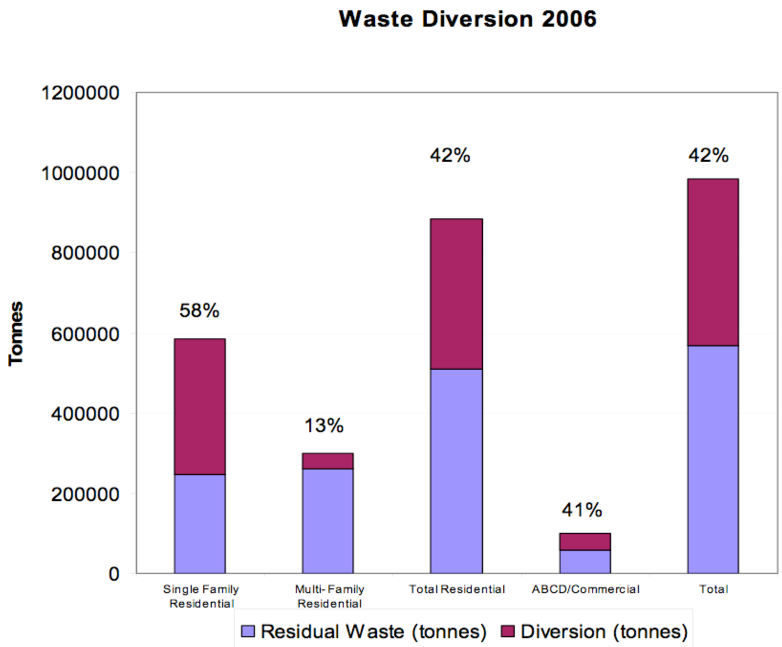

Figure 25. Waste diversion in 2006.
[Source: *Presentation to Council from the Acting General Manager*. Solid Waste Management Services. 2007, p. 2.]

2005 Business Plan
In 2005, Solid Waste Management Services published a multi-year business plan which outlined strategies and programs that would be used to meet the 100% diversion by 2010 goal set by Task Force 2010. The additional 59% diversion (534,745 tonnes) would be accomplished through the diversion initiatives outlined in Table 23. The total cost of this program was estimated to be an incremental $62 million dollars above existing program costs.

Diversion Initiative	New Tonnes of Diversion	% Diverted from Landfill	Additional Annual Operating Cost ($M)	Additional Operating Cost/Tonne
Source Separate Organics in Apartments	34,845	3.8%	$ 6.8	$195/Tonne
Improved Recycling Capacity (Recycling Carts or Additional Blue Boxes)	25,000	2.8%	$ 4.6	$184/Tonne
Additional Recycling Materials Added to Program	11,000	1.2%	$ 0	$0/Tonne
Increase Enforcement – Single Family Homes and Pay As You Throw	29,000	3.2%	($ 1.1)	($38)/Tonne
Increase Enforcement – Multiple Household Locations and Pay As You Throw	40,000	4.4	$ 1.1	$28/Tonne
Reuse Centres	11,850	1.3	$ 6.6	$557/Tonne
Curbside Collection of Durable Goods	21,050	2.3	$ 6.0	$285/Tonne
New and Emerging Technologies	362,000	40%	$ 38.0	$105/Tonne
Total Incremental Changes	**534,745**	**59%**	**$ 62 M Incremental to Current System Cost**	**$116/Tonne Incremental to Current System Cost**

Table 23. Incremental new operating costs of diversion.
[Source: *Multi-Year Business Plan.* Solid Waste Management Services, 2005, p. 8.]

Waste Diversion 70% by 2010

In June 2007, City Council adopted a motion supporting a goal of achieving 70% solid waste diversion by 2010[58], resulting in 250,000 new tonnes. To reach this diversion rate, numerous proposed initiatives were also adopted by Council, including the following:[59]

- **Source Reduction Initiatives.** The city intends to explore its power under the City of Toronto Act to potentially influence waste generation at this early stage.
- **Reuse Centres.** The City will establish approximately six reuse facilities across the City to receive and redistribute reusable and recyclable goods.
- **Green Bin in Apartments.** This program is proposed to be phased in over one and a half years, diverting approximately 30,000 tonnes of organic waste.
- **New Recycling Containers/Products.** New Blue Box containers will be available in larger and varying capacities.
- **New Materials for Blue Box.** New materials such as plastic film and polystyrene may be added to the list of acceptable materials.

Funding for Diversion Programs

This additional diversion will add an incremental cost to the annual Solid Waste Management Services budget of $54 million dollars[60], split evenly between Operating and Capital Financing.

Options for funding this program are:

- the existing method – the property tax base
- volume rate structure – charged directly to single and multi-residential customers.

2007 Operating Budget

Category	Operating Cost ($M)
Program Support Services	29
Collections	97
Transfer	23
Processing	37
Disposal	54
Total	**240**
Revenues	(56.5)
Net Operating Costs	**183.5**

Table 24. Solid Waste Management Services – operating costs in 2007.
[Source: Toronto Solid Waste Management Services]

[58] Executive Committee Report - Meeting No. 9. EX9.1 Proposed Initiatives and Financing Model to Get to 70% Solid Waste Diversion by 2010 (Ward: All). Considered by City Council on June 19, 20 and 22, 2007.
[59] Proposed Initiatives & Financing to Get to 70% Solid Waste Diversion by 2010, Background Report to Executive Committee. SWMS and Deputy City Manager and CFO, May 14, 2007.
[60] The current operating budget is $183.5 million. (Toronto SWMS, 2007)

Solid waste management is one of the most complex issues facing the City of Toronto in its efforts to become a leader in sustainability. The intricacies lie in the variety of waste streams, collection and processing methods required, and the behavioural changes and corporate responsibility which are essential to successfully diverting waste from landfill.

The City of Toronto has been working towards 100% diversion of solid waste from landfill for the ten years since amalgamation, and its current plan known as *Target 70* proposes a 2010 target of 70% diversion. Based on preliminary estimates, approximately 400,000 tonnes of waste from the City of Toronto were diverted from landfill in 2007.

In June 2007, the diversion goals for 2010 previously set were officially revised when City Council adopted a motion supporting a goal of achieving 70% diversion by 2010[61]. To this end, numerous initiatives proposed by SWMS were also adopted by Council, including the following[62]:

- *Source Reduction Initiatives*
- *Reuse Centres*
- *Green Bin program in multi-unit residential buildings*
- *New Recycling Containers/Products*
- *New Materials for Blue Box*

Target 70 is expected to extend the life of Green Lane to 2034, calling for 250,000 tonnes of new material to be diverted, including 75,000 from residual-waste processing.[63] This additional diversion will add an incremental cost to the annual Solid Waste Management Services budget of $54 million dollars, split evenly between Operating and Capital Financing.[64]

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[61] Executive Committee Report - Meeting No. 9. EX9.1a Proposed Initiatives and Financing Model to Get to 70% Solid Waste Diversion by 2010 (Ward: All). Considered by City Council on June 19, 20 and 22, 2007. http://www.toronto.a/legdocs/mmis/2007/cc/bgrd/ex9.1a.pdf

[62] *Proposed Initiatives & Financing to Get to 70% Solid Waste Diversion by 2010, Background Report to Executive Committee.* SWMS and Deputy City Manager and CFO, May 14, 2007. http://www.toronto.ca/legdocs/mmis/2007/ex/bgrd/backgroundfile-3799.pdf

[63] Geoff Rathbone (SWMS), as quoted in *Meeting Minutes.* Community Environmental Assessment Team (CEAT). May 22, 2007. p. 2. http://www.toronto.ca/garbage/ceat/pdf/2007-05-22_minutes.pdf

[64] Executive Committee Report - Meeting No. 9. EX9.1b Presentation to Council from the Acting Manager SWMS. June 19, 20 and 22, 2007. p. 3. http://www.toronto.ca/legdocs/mmis/2007/cc/bgrd/ex9.1b.pdf

Solid Waste Management Synopsis

From the perspective of the Places to Grow directive from the provincial government, which covers the period up until 2031, it appears the City of Toronto is able to manage its solid waste within the existing framework of facilities and the Green Lane landfill site. But how sustainable is the current approach beyond that time?

The goal of waste management, in any country, should be to reduce the total amount of garbage generated, while reusing as much of what remains. In Sweden, more than 90 per cent of household waste is recycled, reused or recovered. By contrast, Toronto diverts about half of its household garbage from landfill and Ottawa diverts about one-third. Things began to change when the Swedish government made the producers and distributors of goods responsible for the waste they create. By law, companies are responsible for collecting the entire waste stream stemming from their products, either on their own or through public or private contractors.

Thanks to a well-developed district energy system, household waste is turned into heat and electricity for hundreds of thousands of Swedish homes. Waste-to-energy through incineration has, in Canada at least, a reputation as an environmentally hazardous process. The truth is that modern technology has cut emissions dramatically, particularly in the case of dioxins. Fifteen years ago, 18 Swedish waste incineration plants emitted a total of about 100 grams of dioxins every year. Today, the collective dioxin emissions from all 29 Swedish waste incineration plants amounts to 0.7 of a gram ... quite an improvement. At the same time, these plants have more than doubled the amount of energy produced in 1985. I had the opportunity to visit a Swedish waste-to-energy plant in Malmö and was amazed at how clean and technologically advanced it was.

[Source: Magnus Schönning, Light House Sustainable Building Centre. May 10, 2006. http://www.sustainablebuildingcentre.com/forum-topic/as_toronto_battles_to_find_a_solution_to_its_garbage_crisis_sweden_offers_a_solution]

"One question that hasn't yet been thoroughly answered is what to do with landfills once they reach full capacity. Parks and golf courses are always possible uses, but with increasing pressure to urbanize surrounding areas, planners are looking for alternative options. The sheer size of the mountains that are created by the industry present unique design challenges; the residual topography of landfilling will be one of the lasting monuments of the North American Empire."

Wasteland. Pierre Bélanger, Editor. Faculty of Architecture, Landscape and Design, University of Toronto, 2005.

Waste to energy is another highly controversial issue that refuses to go away, much like our garbage. At this point in the study, it is not possible to conclude the most cost effective means of addressing the post-occupancy management of solid waste. Concepts like packaging regulations and requiring manufacturers of products to deal with their products' waste streams go beyond the scope of the Toronto Green Development Standard. Ensuring that every new development provides suitable facilities for the source separation of waste streams is entirely feasible. During the construction process, source separation is a fairly straightforward process that has been demonstrated on numerous LEED projects across the GTA. It is only considered more expensive by developers and builders today because the tipping fee structure at landfills and enforcement of regulations (fines) have not been appropriately applied. Anecdotal evidence from the industry suggests that C&D waste management costs less than one-tenth of one percent of total project cost, but further study of this waste management process is needed to provide statistically valid estimates. Regardless of the cost, reduction and diversion over the life cycle of proposed building developments are key to any sustainable solid waste management program implied within the requirements of the Toronto Green Development Standard.

Renewable Energy and District Energy Systems

The green development industry in other developed countries continues to deploy renewable energy and district energy systems to displace or augment centralized energy production technologies. The reasons for this trend will be examined later, but this part of the cost-benefit study simply seeks to assess if the renewable energy and district energy technologies are suited to the needs of urban development forecast in the Greater Toronto Area & Hamilton, and hence for the Greater Golden Horseshoe. Their cost effectiveness will also be assessed, but generically rather than through the types of detailed energy and economic analyses employed from energy conservation measures in buildings.

Renewable energy and district energy systems are considered jointly in this study because in many cases, the two are most cost effectively implemented together. District energy systems often employ combined heat and power systems, and these can be run using bio-fuels, a renewable energy source. The assessment that follows begins by examining autonomous renewable energy systems that can be integrated into a new development. This is followed by an examination of district energy systems, in particular those employing combined heat and power systems that can be adapted to bio-fuels (biomass).

Renewable Energy Technologies

In this part of the study, three primary renewable energy technologies are examined: solar energy systems, wind energy systems and geothermal energy systems. Bio-fuels, either in the form of biomass or biogas, are examined later in the discussion involving combined heat and power systems. After each of these three renewable energy technologies are examined, the current renewable energy market in Ontario and its relationship to new development will be reviewed. It is important to note that hydroelectricity, in the form of low impact hydroelectric generation, has not been considered in this study directly, as the potential opportunities within the Greater Toronto Area are not significant. However, access to this form of renewable energy through green power retailers is examined as an alternative or augmented means of incorporating renewable energy within new building developments.

Solar Energy

The most recent assessment of solar energy potential in Ontario was published by the David Suzuki Foundation in 2004 and an overview is excerpted below:[65]

Surveys of the world's solar photovoltaic (PV) market consistently show that [annual] growth rates of 30% or more have become an established trend. These high growth rates are leading to a general continuing downward trend in grid-connected PV system prices. Markets for solar water and space heating are also increasing at impressive rates of about 26% per year. If supportive policies for solar energy are implemented in Ontario the province could install 1,263 MW of PV systems; 800,000 solar domestic hot water systems; 120,000 solar pool heaters; solar passive design in 420,000 new homes; 2,000,000 m^2 of commercial and institutional solar hot water systems; and 825,000 m^2 solar air ventilation systems. The combined energy output of these solar systems has the technically feasible potential of supplying by 2025 the equivalent power that coal provided in 1999, or about half the electricity generated by all of Ontario's nuclear power plants.

Solar energy can be used in Ontario to generate pollution-free electricity and heat for residential, institutional, industrial, and commercial applications. The most promising solar technologies in the short term are those that capture the sun's rays to heat indoor spaces or water, thereby replacing fossil fuels or nuclear energy that would have been used in these applications. These relatively simple and low-maintenance technologies can provide elegant, clean solutions to some of our energy needs. Solar energy currently provides 8% of the average Canadian home's heating requirements (in the form of sunlight entering

[65] Smart Generation: Powering Ontario With Renewable Energy. The David Suzuki Foundation, 2004.
http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

through windows). This proportion of 'solar thermal' energy (converting sunlight into heat) could be easily increased to 22% with minor changes in community planning, building design, and higher standards.

Solar thermal energy can also provide 40–50% of residential hot water heating and 15% of commercial hot water heating requirements at a cost below the current price of electrically heating water (at the equivalent of 8.4 cents per kilowatt hour), while 39% of pools can be heated using solar thermal panels. Solar walls in new construction can replace other energy sources for space heating at the equivalent of 2 cents per kWh. Achieving the province's solar thermal potential will require a mix of regulatory changes (e.g. building codes, zoning by-laws), marketing support programs to raise public awareness and inform builders on solar thermal options, and tax changes to actively promote solar thermal technologies.

These views are echoed in the Renewable is Doable project, a joint study by WWFCanada and the Pembina Institute to identify electricity scenarios for Ontario that would meet future power demands without the use of nuclear power and coal, and that would generate lower greenhouse gas emissions than the plan currently proposed by the Ontario Power Authority.[66,67] A key follow-up study reinforces the view that renewable energy is an effective means of addressing base electrical energy loads in Ontario, and remains a viable alternative to non-renewable energy sources and nuclear technologies.[68]

This next section of the study begins with a review of solar thermal systems used for water heating, since this technology predates photovoltaic technology. An assessment of photovoltaic applications follows, and then the final section on solar energy concludes with an assessment of solar ventilation air pre-heating technology. Passive solar heating of buildings through south facing glazing is not reviewed in this study, but it is important to note that government funded research from the 1970s and 1980s went so far as to develop guidelines for solar site planning and subdivisions. The science of passive solar heating is well understood but somehow this energy conserving, renewable energy strategy fell victim to a cultural amnesia that gripped designers and builders for nearly a quarter century. The recently established Canadian Solar Buildings Research Network (http://www.solarbuildings.ca) has rekindled the potential of solar buildings through a comprehensive program of integrated research projects aimed at optimizing the utilization of solar energy in buildings.

[66] *Renewable is Doable: A Smarter Energy Plan for Ontario. Report 1: Analysis of Resource Potential and Scenario Assumptions*. Roger Peters, Paul Cobb and Mark Winfield, The Pembina Institute, July 2007. http://pubs.pembina.org/reports/RID_report1_final.pdf

[67] *Renewable is Doable: A Smarter Energy Plan for Ontario. Report 2: Analysis and Scenario Modeling of the Ontario Power System*. Marc Godin, Portfire Associates, July 2007. http://pubs.pembina.org/reports/RID_report2_final.pdf

[68] *The Basics on Base Load: Meeting Ontario's Base Load Electricity Demand with Renewable Power Sources - Solutions Paper No. 1*. Roger Peters and Cherise Burda, The Pembina Institute, September 2007. http://pubs.pembina.org/reports/TheBasicsOnBaseload.pdf

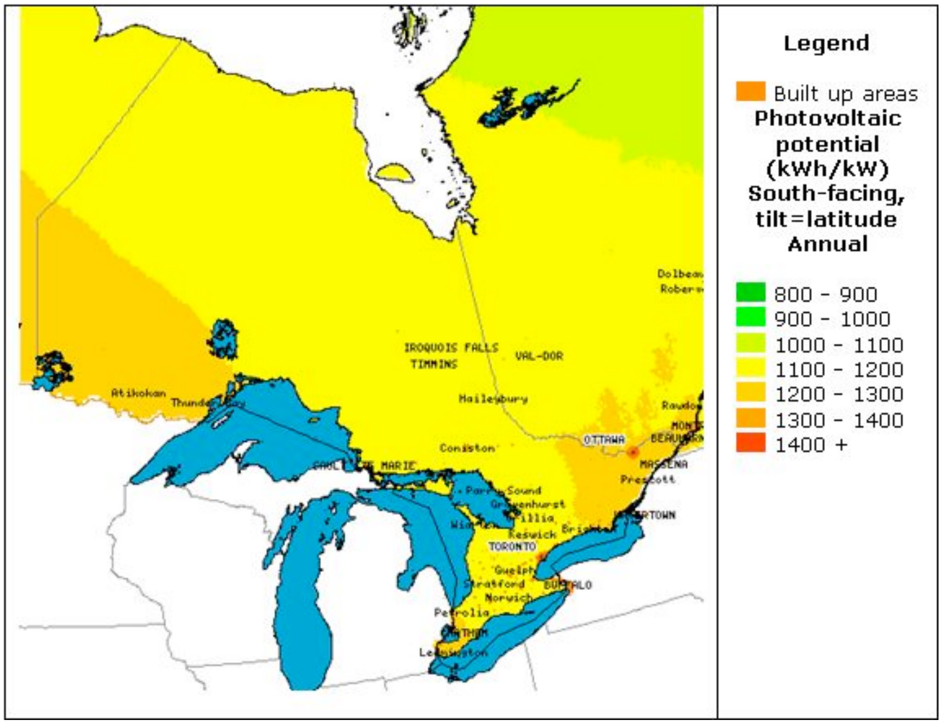


Figure 26. Map of photovoltaic potential in Ontario. [Natural Resources Canada]

Figure 27. The Canadian Solar Buildings Research Network and Canada Mortgage and Housing Corporation's EQilibrium Home Program are developing net zero energy houses that are entirely heated and powered by solar energy. [Photo: Solar Buildings Research Network]

"Solar energy, of course, has many other benefits; primarily independence from foreign suppliers and greatly reduced air and water pollution, including less greenhouse gas. It also offers the option of decentralized energy production, which would reduce the risk to our energy supply from terrorist attacks.
There are those who favor nuclear energy over solar. I can only point out that with solar energy we do not need to worry about deadly 'solar leaks' seeping into the ground and water, and we do not need to figure out how to protect the planet from "solar waste" that will remain lethal for thousands of years.
Time grows short. We must turn to new, plentiful, nonpolluting sources of energy, and we must do this quickly, while we still have enough fossil fuels to power the tools necessary to build solar and wind machines. By doing this, we are not just fulfilling some ideological goal of environmentalists, we are sustaining civilization and one of its finest products, democracy."

Energy and Civilization. Daniel B. Botkin, 2007. http://www.danielbbotkin.com/archives/energy-and-civilization

Solar Water Heaters

Solar energy can be used to heat air and water for residential and commercial buildings, to heat water for pools, and can also be used in industry and agriculture in ways such as crop drying and water heating. Solar water heaters represent a common deployment of solar thermal technologies in the residential sector. The technology is mature, reliable and has numerous manufacturers, suppliers and certified installers.

The three types of solar water heating collectors normally found in residential applications are as follows:

Unglazed collectors are usually made of a black polymer. They do not have a selective coating and do not include a frame and insulation at the back; they are usually simply laid on a roof or on a wooden support. They are good at capturing the energy from the sun, but thermal losses to the environment increase rapidly with water temperature particularly in windy locations. Unglazed collectors are commonly used for applications requiring energy delivery at low temperatures (pool heating, make-up water in fish farms, process heating applications, etc.); they are often operated in the summer season only because of the high thermal losses of the collector. Unglazed collectors are sensitive to wind and often, the efficiency of such collectors include a wind-dependent term.

Glazed collectors often have a selective coating and are fixed in a frame between a glass cover at the front and an insulation panel at the back. They are good at capturing the energy from the sun and their thermal losses to the environment are relatively low. Glazed collectors are commonly used for applications requiring energy delivery at moderate temperatures (domestic hot water, space heating and process heating applications at 50°C or less) in medium to cold climates. They can be operated year-round with freeze protection (e.g. glycol, drain-back design). The efficiency of glazed collectors is independent of wind.

Evacuated collectors have a selective coating enclosed in a sealed, evacuated glass tubular envelope. They are good at capturing the energy from the sun; their thermal losses to the environment are extremely low. Systems presently on the market use a sealed heat-pipe on each tube to extract heat from the absorber (a liquid is vaporised while in contact with the heated absorber, heat is recovered at the top of the tube while the vapour condenses, and condensate returns by gravity to the absorber). Evacuated collectors are good for applications requiring energy delivery at moderate to high temperatures (domestic hot water, space heating and process heating applications typically at 60°C to 80°C depending on outside temperature) in cold climates. They can be operated year-round with freeze protection. The efficiency of evacuated collectors is independent of wind.

The glazed and evacuated type collectors are normally used in residential applications, with the glazed type panels being prevalent due to significantly lower capital costs. The performance of all three technologies can be modeled using RETScreen Solar Water Heater software (available free with documentation at http://www.retscreen.net/) The software has the capability to rapidly and accurately predict solar water heater technology performance and also carry out an economic cost/benefit analysis. As an illustrative example, a typical solar water heating system consisting of 2 panels with a net collection area of 5.4 m^2 was modeled in Toronto. The system contributes an estimated 10.27 GJ to the annual household solar water heating energy demand, which is approximately 16.35 GJ, assuming 225 litres per day of hot water use. In a household with low flow fixtures and water efficient appliances, the annual demand can be reduced to between 10 and 12 GJ.

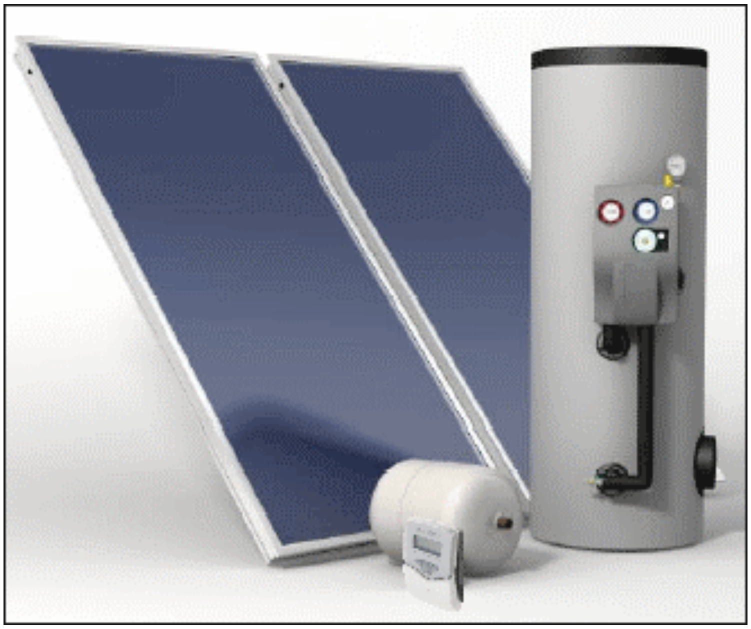


Figure 28. Components of a typical solar water heater system for a single detached home. [Photo courtesy Schüco, LP]

Technology	Range of Life of Systems in Current Operation	Value Used for Calculating Capacity	Range of Current Life Expectancies
Unglazed Water	10-20 years	15/20 years	20-30 years
Glazed Water	20-25 years	15/20 years	20-35 years
Evacuated Tube	15-20 years	15/20 years	15-25 years
Unglazed Air	30-40 years	30 years	30-40 years
Glazed Air	10 years	10 years	Not found

Table 25. System life expectancy by type of solar thermal collector.

[Source: *Final Report of a Survey of Active Solar Thermal Collectors, Industry and Markets in Canada*. Science Applications International Corporation (SAIC Canada) for Natural Resources Canada, August 2005.
http://www.cansia.ca/downloads/STC_survey_2004_-_final_report_050819_new173OXT-02112005-7077.pdf]

Depending on the fuel used for water heating, and the water heater energy conversion efficiency, the annual energy savings in Toronto would range from approximately $250 for natural gas, up to $400 for electricity, assuming a family of four people. Installed costs for basic systems such as the one described here are approximately $6,000 in new homes. In the case of natural gas water heating, the system has a simple payback period of 24 years, equivalent to its expected service life, while for electricity the payback period is 15 years. When the energy price escalation rate is considered over a 25-year period, and the current subsidies and tax credits are applied (approximately $1,000 total credit), the payback periods and rates of return for natural gas heating are 17.4 years & 5.8% and 15.3 years & 7.8% for the current and high energy price escalation scenarios, respectively. In the case of electricity being used for water heating, payback periods and rates of return are 10.1 years & 13.4% and 9.3 years & 15.5%, respectively. In most cases, the system life expectancy equals or exceeds the payback periods, hence the technology is cost effective over its life cycle.

Figure 29. Solar water heater technology is less complicated than in-floor hydronic heating systems and can be reliably installed by plumbing and heating trades.

For industrial, commercial and institutional applications, solar water heating systems are engineered for the specific application. In some cases, energy companies will provide the design and installation of equipment in exchange for a unit energy charge, typically about 8.5 cents per kilowatt-hour at the time of this report. A complete systems approach to water conservation can usually reduce hot water consumption in buildings such that the slight premium for solar heated water is offset by lower hot water consumption.

Mondial Energy installs Ontario's largest roof-top solar heating system
Mondial Energy installation to reduce greenhouse gas emissions by 61 tonnes per year
TORONTO, Sept. 12 /CNW/ - Mondial Energy Inc. has installed Ontario's largest, most powerful solar thermal heating system at one of WoodGreen's affordable housing sites on Toronto's Queen St. East. The installation is a partnership between WoodGreen Community Services and Mondial Energy, which builds and owns solar sites on commercial, residential and municipal buildings.

"By providing the capital for the installation, Mondial breaks the up-front cost barrier and by assuming the ongoing maintenance responsibility, we also break the technology risk barrier," said Alex Winch, President, Mondial Energy. "For 100 per cent clean energy, this is both an attractive and an affordable alternative, especially for non-profit organizations that are committed to the environment."

Consisting of 108 glazed flat plate solar collectors, the installation at 1070 Queen St. East will generate 34 per cent of the total annual hot water requirements at the 170-unit building. WoodGreen Community Services will only pay for the solar thermal energy delivered to the building at a fixed 10-year rate. The custom-designed solar thermal energy system will be paid for, owned and operated by Mondial Energy.

"Like many other organizations looking for ways to go green and reduce their impact on the environment, we felt it was important to lead the way in our sector," said Brian Smith, President and CEO, WoodGreen Community Services. "With no upfront capital cost for changing to solar, this installation allows us to use our limited capital resources for other critical services for our clients." Taylor Munro Energy Systems of Vancouver designed and installed the solar array.

[Source: Canada News Wire Group, September 12, 2007.
http://www.newswire.ca/en/releases/archive/September2007/12/c7670.html]

Photovoltaics

Photovoltaic (PV) devices, or solar cells, convert sunlight directly to electricity. PV technologies were invented approximately 45 years ago at AT&T's Bell Laboratories in the United States and were initially used to power satellites and space vehicles. In the past two decades, research and development have improved the efficiency and reliability of photovoltaics, and reduced their cost by a factor of five.

Photovoltaic systems are now predominantly used for terrestrial applications where battery charging in off-grid applications is required. Photovoltaic or solar cells are generally made of a semiconductor material. Individual cells are interconnected and encapsulated to produce modules or panels that produce a specific amount of peak power. Other key components of a photovoltaic system are the inverter (DC to AC conversion), the mounting structure, and the battery and charge controller (for off-grid systems). At present the vast majority of photovoltaic cells are made from silicon, either crystalline (sliced from ingots or castings or grown ribbons) or thinfilm (deposited in thin layers on a low cost backing).

Single crystal silicon cells are manufactured from single crystal ingots that are then sliced into wafers, and utilise processes typical of the silicon semiconductor industry.

Multicrystalline cell manufacture usually begins with a casting process in which molten silicon is poured in a rectangular block. This produces a block of multicrystalline silicon that is then sliced into wafers that are used to make square solar cells. One way of eliminating the sawing step is to grow ribbons of multicrystalline silicon that are already wafer thin and the correct width for use as PV cells. Present conversion efficiencies (solar energy to electrical energy) for commercial modules are in the range of 12 to 15%, however, incremental improvements to manufacturing processes are expected to lead to commercial module efficiencies of 18% by 2010. Even higher efficiencies can be obtained and the maximum recorded solar cell efficiency for crystalline silicon to date is 24.7%.

Thin film modules are constructed by depositing thin layers of photovoltaic materials on a low cost backing such as glass, stainless steel or plastic. Individual “cells” are formed by then scribing through the layers with a laser. Thin film cells offer the potential for cost reductions because material costs are lower and labour costs are reduced since the films are produced as large, complete modules rather than as individual cells that have to be interconnected, laminated and mounted in frames. The most developed thin film technology is amorphous silicon. The efficiency of commercial amorphous silicon modules has improved from around 3.5% in the early 1980s to over 7% at present. The most efficient modules are made with multiple layers of photovoltaic material, which have a record cell efficiency of 13.5%.

PV technology type and recorded efficiencies.

Technology type	*Typical module efffiency*	*Max. recorded module efficiency*	*Max. recorded lab. cell efficiency*
Single crystalline silicon	12-15%	22.7%	24.7%
Multicrystalline silicon	11-14%	15.3%	19.8%
Amorphous silicon	5-7%	-	12.7%[15]
Silicon-Film	-	9.79%[14]	16.6%
Spheral Solar™	-	10.3	-

Table 26. Efficiencies of various contemporary PV technologies.
[Source: Ayoub, J., Dignard-Bailey, L., and Filion, A. *Photovoltaics for Buildings: Opportunities for Canada: A Discussion Paper*. Report # CEDRL-2000-72 (TR), CANMET Energy Diversification Research Laboratory, Natural Resources Canada, Varennes, Québec, Canada, November 2000, pp. 56 (plus annexes). http://cetc-varennes.nrcan.gc.ca/fichier.php/codectec/En/2001-123/2001-123e.pdf]

The capability to predict photovoltaic system performance is now readily accessible and reliable. For advanced system designs, RETScreen software is available to carry out detailed analyses (http://www.retscreen.net). An easier to use Web accessible source is available at *Photovoltaic Potential and Solar Resource Maps of Canada* https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php.

At this site, photovoltaic potential (kWh/kW) and mean daily global insolation (MJ/m^2 and kWh/m^2) data are presented below for the selected municipality. Data are presented for each month and on a yearly basis for 6 different PV array orientations. Table 27 has been reproduced for Toronto, Ontario.

Photovoltaic (PV) electricity generation potential for grid-connected photovoltaic systems without batteries (in kWh per kilowatt of photovoltaic installed power capacity) was estimated from the insolation models for all fixed surface orientations for each grid cell using a performance ratio of 0.75. The performance ratio quantifies and takes into account overall system losses due to operation under non-ideal conditions: climatic factors, inverter operation and so on.

Toronto, Ontario: Geographic location -> -79.39E,43.65N				
	South-facing vertical (tilt=90°)	South-facing, tilt=latitude	South-facing, tilt=latitude+15°	South-facing, tilt=latitude-15°
January	67	66	70	59
February	77	82	84	75
March	86	108	106	104
April	70	113	104	117
May	63	122	107	131
June	59	123	106	136
July	63	129	111	141
August	68	121	108	127
September	71	103	98	103
October	74	89	89	84
November	52	55	58	50
December	52	51	55	45
Annual	801	1161	1095	1173

Table 27. PV potential - kWh collected per kW installed PV capacity, Toronto.

Using this example for Toronto, and assuming a typical household electrical energy consumption of some 9,000 kWh annually, approximately 8 kW of photovoltaic panels would have to be installed on a tilted, south-facing roof to satisfy electrical energy demands on an annualized basis. Various solar energy suppliers in the Toronto area were contacted to estimate an installed cost for a system of this size, and quoted prices ranged from $35,000 to $40,000 for a grid-tied system. The cost of batteries to provide energy autonomy in case of a grid blackout would add approximately $5,000 to the cost, depending on the peak draws from the storage system. From a purely economic perspective, it would be more cost effective, in most cases, to reduce the size and cost of the system and to use part of the savings to pay premiums for energy efficient electrical appliances and lighting. Assuming household energy consumption could be reduced by half, down to 4,500 kWh per year, similar to the European average, a net zero energy photovoltaic system with battery backup would cost approximately $25,000. Under the most favourable circumstances, if all of the PV generated electricity was sold to the grid at $0.42 per kWh, and the household purchased this same amount at $0.10 per kWh, the system would generate $1,440 in revenue and produce a simple payback after some 17.4 years (not taking into account the replacement of the battery bank). When energy price escalation is considered, the payback periods and rates of return are 13.2 years & 9.5% under the current scenario, 11.9 years and 11.5% under the high scenario.

Clearly, the current cost of PV systems poses an economic barrier in terms of its initial cost. Under current market conditions, it is reasonable to conclude that in the absence of significant subsidies, this technology has a longer term time horizon than solar water heaters. But there are alternative perspectives on the cost effectiveness of PV energy technologies. The first is based on its real market value and utility.

Research conducted by Professor Ian Rowlands of the University of Waterloo indicates that in the case of Ontario, "*solar radiation values coincide closely with peak market demand and, though to a somewhat lesser extent, peak market prices during the summertime*."[69] This tends to support the view that PV technology should be compared against the cost effectiveness of other peak electrical energy generating technologies, rather than the average electrical price mix in Ontario. More recent work by Rowlands suggests that, "*Placement of PV systems should be encouraged in areas of high congestion such as southwestern Ontario, in particular the GTA. This will help to maintain system reliability, alleviate transmission and distribution costs and offset future capital costs of expanding transmission infrastructure*."[70]

Figure 30. Innovative PV technologies integrate energy collection with functional elements such as roof cladding. [Photo courtesy CMHC.]

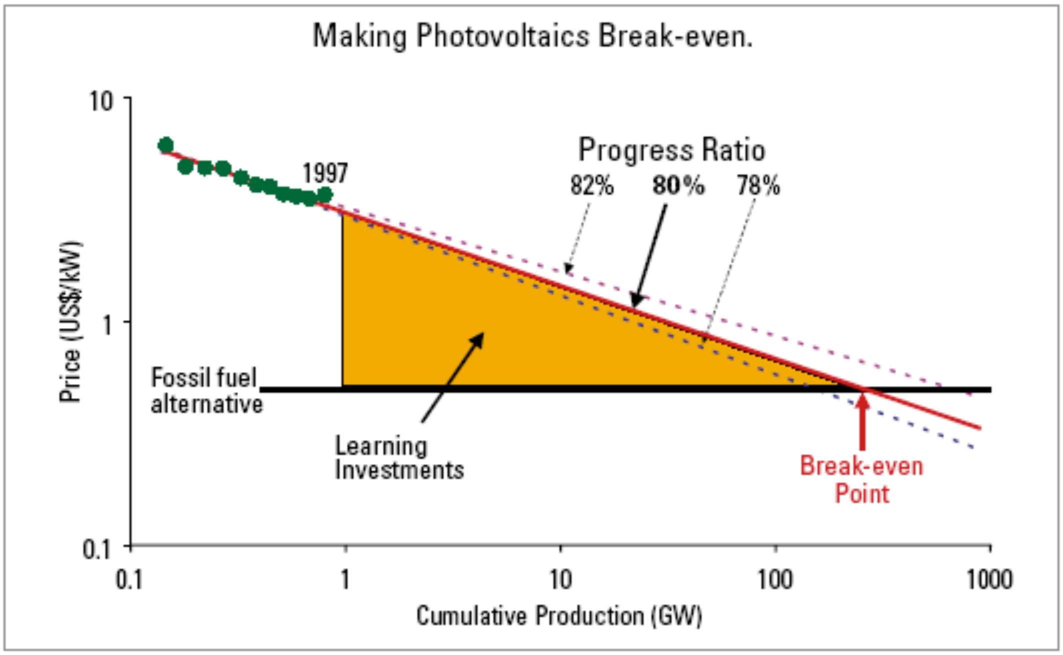
The second is based on affordability versus willingness to pay. Since 1996, household repairs and renovations have been on the upswing. According to Statistics Canada, Canadians spent $11.8 billion (current dollars) in terms of household repairs and renovations in 1996. By 2001, figures had climbed 72 per cent to $20.4 billion, and by 2002 reached $23.4 billion.[71] 2006 census data has not been released, but the recently witnessed trend is expected to hold. It is not uncommon for a kitchen renovation to exceed the cost of an extensive PV system, yet it does not offer a payback, improve energy security and reduce greenhouse gas emissions.

[69] Ian H. Rowlands, *Solar PV Electricity and Market Characteristics: Two Canadian Case-Studies*, Renewable Energy (Vol. 30, No. 6, May 2005), pp. 815-34.
[70] Rowlands, I.H., and S. J. Brown, *Nodal Pricing in Ontario – Implications for Solar PV*. Renewable Energy, in press.
[71] Statistics Canada, http://www.statcan.ca/Daily/English/031118/d031118b.htm

Figure 31. Thin film PV technologies integrated into glazing can provide both energy collection and environmental separation. [Photo courtesy CMHC]

Figure 32. PV technology and solar water heaters are common in European housing where large subsidies have been made available to homeowners for their installation. Note the inclusion of biomass space heating. [Photo courtesy International Energy Agency]

The experience curve for photovoltaic module prices versus cumulative sales over the past 20 years has a progress ratio between 80% and 82% - a value that falls within the range typical for manufactured goods. Thus, the resultant overall learning rate for photovoltaic modules between 1977 and 1997 is approximately between 18% and 20%. The breakeven point for sales of photovoltaic modules (at a progress ratio of 80%) would be reached around the 300 GW cumulative production. Based on annual growth rates of 20%, the break-even point for the current technology to compete with bulk electricity generation in Canada, based simply on lowest production cost, will be reached within the 2020-2030 time-frame.



Source: Class-Otto Wene, *Experience Curves for Energy Technology Policy*, IEA/OECD, Paris, France, 2000.

Figure 33. Extrapolation of cumulative global PV production needed to reach a breakeven point with fossil fuel energy alternatives.

[Source: *Photovoltaics for Buildings: Opportunities for Canada*. Natural Resources Canada, November 2000.]

Projected cost reduction of solar electricity (constant 1997 US$).				
	1997	*2010*	*2020*	*2030*
Cost of energy (US$/kWh)	0.30	0.14	0.08	0.047

Source: *Adapted* from the EPRI-DOE study:*Renewable Energy Technology Characterization*, www.eren.doe.gov/utilities/techchar.html.

Table 28. Projected cost of electrical energy generated by PVs up to 2030.

[Source: *Photovoltaics for Buildings: Opportunities for Canada*. Natural Resources Canada, November 2000.]

Since this November 2000 study was published, PV technology efficiency has improved, costs have decreased and time-of-use electricity rates are poised for implementation in Ontario. These factors are likely to cause PV-generated electricity to become cost competitive in the 2010-2020 timeframe.

Solar Ventilation Air Preheater Technology

In cold climates like Ontario, well-insulated, airtight exterior envelopes are used to achieve energy efficiency. In such cases, bringing in make-up air to meet ventilation requirements can be problematic, as it should be preheated to avoid occupant discomfort during cold weather. Pre-heating is conventionally performed using make-up air heaters that consume large amounts of energy. The solar ventilation air pre-heater has exterior corrugated steel cladding perforated with tiny holes that allow fresh air to penetrate. An air space (between the cladding and the exterior wall finish) under negative pressure draws air in through the holes, and is collected in a canopy plenum (which has a by-pass damper for summer). A fan and distribution ducting direct the air through the building's ventilation system.

Properly designed and installed, these systems can improve the thermal effectiveness of the wall assembly during cold periods shade the south wall in summer to reduce cooling loads. Advanced systems come with thin-film photovoltaic collectors integrated into the preheater cladding system.

In order to be more efficient, the system requires a large unglazed south-facing wall area, a cool climate, and/or a relatively high ventilation load. Additional mechanical heating may be required for the make-up air on cloudy or very cold or windy days.

Figure 34. Example of solar air heating panels attached to south facing wall of a high school. [Photo courtesy Conserval Engineering]

RETScreen software contains a module for assessing the cost effectiveness of solar ventilation air preheaters (http://www.retscreen.net). Typically, the cost of this technology is $10 to $15 per square foot of wall area, including labor and materials, yielding simple payback period of 2 – 4 years in new buildings. For existing building retrofits, approximately 6 – 7 years is required to recover the investment. In order to be more efficient, these systems require a large unglazed south-facing wall area, a cool climate, and/or a relatively high ventilation load. Additional mechanical heating may be required for the make-up air on cloudy or very cold or windy days. A made in Ontario system is manufactured by Conserval Engineering.

Geothermal Energy Systems

Geothermal energy systems are known variously as geothermal heat pumps (GHP), ground source heat pumps (GSHP), and earth energy systems (EES). They represent a mature technology that is being reviewed in this study due to recent improvements in energy efficiency combined with reductions in capital costs. A geothermal heat pump uses the thermal energy of the ground or groundwater as the heat source and heat sink for building space heating and/or cooling, and in some cases, domestic water heating. A typical geothermal heat pump system consists of a packaged unit located inside of the building that houses a compressor, primary and secondary heat exchangers, and desuperheater for domestic water heating. This is connected to some form of ground heat exchanger located outside of the building.

Type of Geothermal Heat Pump	EER	COP	Water Heating
Closed Loop	14.1	3.3	Yes
With integrated WH	14.1	3.3	N/A
Open Loop	16.2	3.6	Yes
With integrated WH	16.2	3.6	N/A
DX	15	3.5	Yes
With integrated WH	15	3.5	N/A

Table 29. Key energy efficiency performance criteria for Energy Star qualified geothermal heat pump systems. [Source: Energy Star.]

There are three types of geothermal heat pump systems based on their mode of energy exchange:

Closed Loop System - A ground heat exchanger in which the heat transfer fluid is permanently contained in a closed system.

Open Loop System - A ground heat exchanger in which the heat transfer fluid is part of a larger environment. The most common open loop systems use ground water or surface water as the heat transfer medium.

Direct Expansion (DX) - A geothermal heat pump system in which the refrigerant is circulated in pipes buried in the ground, rather than using a heat transfer fluid, such as water or antifreeze solution in a separate closed loop, and fluid to refrigerant heat exchanger. A DX system includes all of the equipment both inside and outside the house. DX systems may be single or multi-speed.

Other useful terms related to geothermal heat pump systems include:

COP: Coefficient of Performance — A measure of efficiency in the heating mode that represents the ratio of total heating capacity to electrical energy input.

EER: Energy Efficiency Ratio — A measure of efficiency in the cooling mode that represents the ratio of total cooling capacity to electrical energy input. For DX systems, EER will be calculated in accordance with the CSA Standard C748-94 Performance of Direct Expansion (DX) Ground Source Heat Pumps.
[Source: Geothermal Heat Pumps Key Product Criteria.
http://www.energystar.gov/index.cfm?c=geo_heat.pr_crit_geo_heat_pumps]

Energy Efficiency Considerations

As with air-source heat pumps, earth-energy systems are available with widely varying efficiency ratings. Earth-energy systems intended for ground-water or open-system applications have heating COP ratings ranging from 3.0 to 4.0, and cooling EER ratings between 11.0 and 17.0. Those intended for closed-loop applications have heating COP ratings between 2.5 and 4.0, while EER ratings range from 10.5 to 20.0.

The minimum efficiency in each range is regulated in the same jurisdictions as the air-source equipment. There has been a dramatic improvement in the efficiency of earth-energy systems efficiency over the past five years. Today, the same new developments in compressors, motors, and controls that are available to air-source heat pump manufacturers are resulting in higher levels of efficiency for earth-energy systems.

In the lower to middle efficiency range, earth-energy systems use single-speed rotary or reciprocating compressors, relatively standard refrigerant-to-air ratios, but oversized enhanced-surface refrigerant-to-water heat exchangers. Mid-range efficiency units employ scroll compressors or advanced reciprocating compressors. Units in the high efficiency range tend to use two-speed compressors or variable speed indoor fan motors or both, with more or less the same heat exchangers.

Sizing Considerations

Unlike the outside air, the temperature of the ground remains fairly constant. As a result, the potential output of a geothermal heat pump varies little throughout the winter. Since the output is relatively constant, it can provide almost all the space heating requirements with enough capacity left to provide hot water heating.

As with air-source heat pump systems, it is not generally a good idea to size an earth energy system to provide all of the heat required by a building. For maximum cost-effectiveness, an EES should be sized to meet 60 to 70 percent of the total maximum "demand load" (the total space heating and water heating requirement). The occasional peak heating load during severe weather conditions can be met by a supplementary heating system. A system sized in this way will in fact supply about 95 percent of the total energy used for space heating and hot water heating.

Geothermal heat pumps with variable speed or capacity are available in two speed compressor configurations. This system can meet all cooling loads and most heating loads on low speed, with high speed required only during periods with high heating loads. A variety of sizes are available to suit the Canadian climate. Units range in size from 0.7 kW to 35 kW (2 400 to 120 000 Btu/h) for housing and small buildings, and include domestic hot water (DHW) options. Systems for larger commercial and institutional buildings consists of a series of smaller equipment, often controlled for staged operation to correspond with heating and cooling demands.

[Source: Heating and Cooling with a Heat Pump, Office of Energy Efficiency, Natural Resources Canada. http://oee.nrcan.gc.ca/publications/infosource/pub/home/Heating_and_Cooling_with_a_Heat_Pump_Section4.cfm]

In urban settings, geothermal heat pumps are usually connected to some form of ground or groundwater exchange. As a result, geothermal heat pump technology may prove unattainable depending on the availability of land in which to install the ground exchange loop. The following information excerpted from CanREN indicates the types of ground exchange options available.

Ground-Water Heat Pump (GWHP) Systems

Where ground water is available in sufficient quantities with adequate quality and environmental regulations permit this type of installation, such a system should be considered. GWHP systems will generally be more economically attractive for larger buildings, since the cost of the ground-water wells (supply and injection) does not rise linearly with capacity.

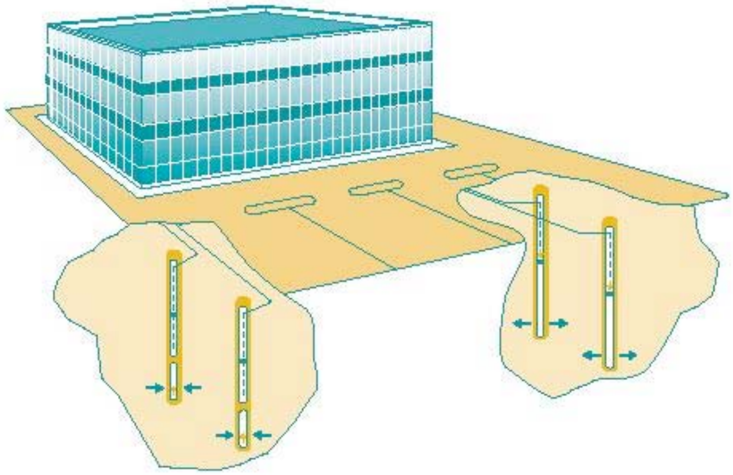


Figure 35. Typical ground-water heat pump system. [Source: CanREN]

GWHP systems were the first to appear on the market. These systems have been used successfully for decades. However, local environmental regulations and insufficient water availability may limit their use in some areas. A GWHP earth connection consists simply of water wells where ground water from an aquifer is pumped directly from the well to the building and, commonly, returned to the aquifer by another well. In such cases, the supply and return wells should be spaced to avoid thermal interference. As described earlier, an intermediate heat exchanger may be used to isolate the heat pumps from the well water. This is done to protect the heat exchanger from the fouling, abrasive or corrosive action of the well water. After leaving the building, the water can be pumped back into the same aquifer via a second well, called an injection well. Pumping power requirement is often an important factor to consider when evaluating ground-water systems.

Vertical Ground-Coupled Heat Pump (GCHP) Systems

Vertical GCHP systems are well suited for most commercial buildings and are usually the least expensive GCHP option for larger buildings. The GHX can be located under the building footprint or parking lot, making optimal use of available land. It has minimal environmental impact, and the earth connection in such systems can also be used, when properly designed, as a heat storage medium (i.e., for free cooling and sometimes free heating).

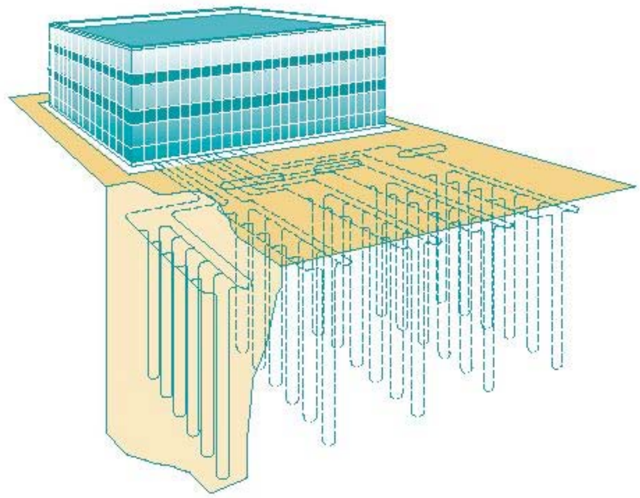


Figure 36. Typical vertical ground-coupled heat pump system.
[Source: CanREN]

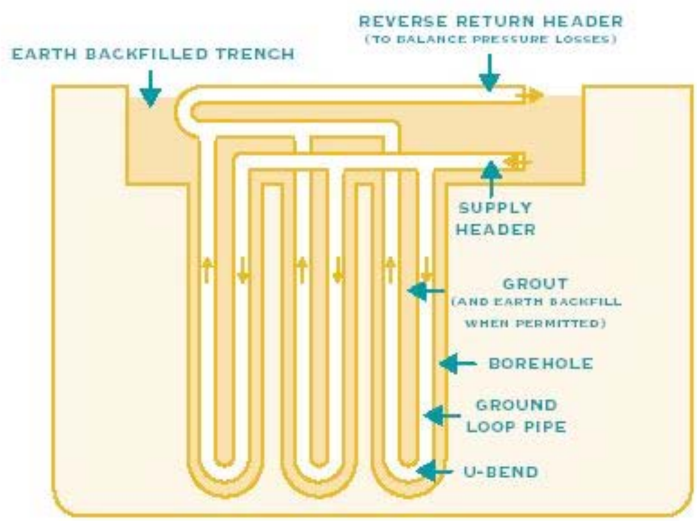


Figure 37. Schematic of vertical ground-source heat exchanger.
[Source: CanREN]

This type of system is well suited for most soil conditions and when minimum disruption of the landscaping is desired. The system consists of a series of vertical holes (boreholes) in the ground at 45 to 150 metres deep, into which one or two high-density polyethylene U-tubes (one down-flow tube and one up-flow tube in the same well) are placed. After the pipe is inserted, the hole is backfilled and grouted. The grouting process consists of filling the borehole with a special material that will prevent surface water from penetrating the aquifer or prevent the water from one aquifer from leaking into an adjacent one. Grouting materials usually have poorer heat-transfer characteristics than common backfill material and cost more, but thermally enhanced grout is also available (i.e., bentonite). Grouting the boreholes from top to bottom is often recommended for adequate protection from water seepage from one aquifer to another. In all cases, local environmental regulations must also be consulted. Following backfilling and grouting, the vertical pipes are connected to a horizontal underground header pipe. The header pipe carries the GHX fluid to and from the heat pumps. Vertical loops are generally more expensive to install than horizontal ones (for small projects), but require less piping due to the higher efficiency obtained at greater depths.

Horizontal Ground-Coupled Heat Pump Systems

A horizontal ground-coupled system configuration is often the most economical to install, offering the lowest initial cost. However, these systems will also often have lower seasonal efficiencies because of lower ground temperatures and they require a larger land area. Generally, when the system's cooling capacity exceeds 70 kW, the surface of a typical parking lot will not be sufficient to accommodate the GHX without supplemental heat rejection. For these reasons, horizontal GCHP systems are usually more suited for smaller applications such as residential and small commercial buildings. Imbalances between the heating and cooling loads must be properly addressed in these systems to ensure that the ground surrounding the loop will offer a stable, long-term source and sink for the EES.

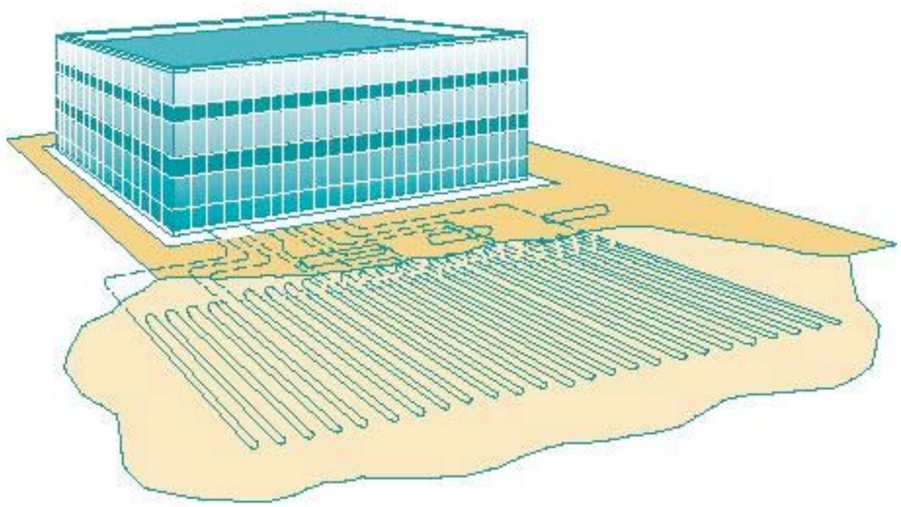


Figure 38. Typical horizontal ground-coupled heat pump system.
[Source: CanREN]

Horizontal GHXs consist of a series of pipes laid out in trenches, usually one to two metres below the ground surface. Up to six pipes per trench can be specified, with adequate spacing between them. Typically, about 35 to 55 metres of pipe is installed per kW of heating and cooling capacity. Many variations of the horizontal GHX can be used. When land area is limited, a coiled pipe – also called a "slinky" or spiral – may be used in order to fit more piping into a trench area. Although this reduces the amount of land used, it will require more pipe, which results in additional costs. Once the pipe is laid out, the trench is then backfilled.
[Source: *Selecting and Earth Energy System*. Canadian Renewable Energy Network. http://www.canren.gc.ca/prod_serv/index.asp?CaId=169&PgId=997]

Geothermal Systems Cost Effectiveness

The most comprehensive database of cost effectiveness assessments is available through the Canadian Renewable Energy Network (CanREN).
http://www.canren.gc.ca/renew_ene/index.asp?CaId=48&PgId=368

In March 1999, CanREN published an extensive study conducted by Marbek Resource Consultants entitled, *Ground Source Heat Pump Market Development Strategy*. An Executive Summary is available at:
http://www.canren.gc.ca/prod_serv/index.asp?CaId=151&PgId=771#Annex

In this study, an extensive life cycle cost analysis was performed and the results were summarized in a series of tables available at:
http://www.canren.gc.ca/app/filerepository/AFC34E9A3009438284C549ADB6A85831.pdf

Excerpted from this study is the following discussion where the ground source heat pump is compared with a natural gas fuelled system (Note that natural gas prices have escalated far more steeply than electricity since 1998.):

The tables show the following results:

- *Of the total 135 GSHP options, covering 12 building types and four geographical regions, only 10 did not generate life-cycle costs below that of the base case system.*
- *Six of the 10 scenarios that did not pass are comparisons with gas base case systems. Gas prices (per unit of energy input) tend to be lower than either electricity or oil.*
- *Eight of the 10 scenarios that did not pass actually fall into the category of "marginal", suggesting that even in these situations, the GSHP systems could compete successfully.*
- *Payback periods are shown to range from 0 (those cases that show a lower capital cost for the GSHP system compared to the base case) to a high of 40 years for elementary schools in Toronto. The average payback period for all the segments and regions is approximately 6 years with most falling in the 4 to 8 year range.*
- *The buildings with the best payback periods are the offices (both the high tech and the suburban office) which have payback periods of 0 years. The next segments with the best payback periods are arenas and curling rinks which show payback periods of 1 to 5 years. The third best segment is the high school with payback periods of 4 to 6 years.*
- *The cost increment of the GSHP system is lower in the office segment and some of the curling rinks. This is due to the trade-off in mechanical equipment between the base case and the GSHP configuration.*
- *Both from an LCC and payback period standpoint, the potential "winners" cut across all of the target building segments. The "weakest" results pertain to the elementary schools. This appears to be due to the fact that these buildings are assumed to have a very low seasonal heating load.*

Table 30. Payback Periods for EES (in years) Compared with Gas Base Case*
[Source: http://www.canren.gc.ca/prod_serv/index.asp?CaId=169&PgId=996]

	Montréal	Toronto	Vancouver
New elementary school (3000 m²)	13.6	18.3	1.3
Seniors' complex (7800 m²)	7.6	10.8	1.8
High-technology facility (7000 m²)	–	Immediate	–
Curling rink/hockey arena (1100 m²)	4.8	Immediate	–
Mid-size hotel (10 500 m²)	5.9	9.5	6.1
Motel (2050 m²)	5.4	8.3	5.7
Suburban office building (5200 m²)	Immediate	Immediate	Immediate
Strip mall	4.9	5.4	–

* LCC results based on 1999 prices. As fuel prices rise, payback periods grow shorter.

Geothermal heat pumps represent a cost effective means of tapping into solar energy stored in the earth on a seasonal basis. Unlike conventional heating and cooling systems, they avoid the use of fossil fuels (unless the electricity to power them comes from 'dirty' sources) and do not result in noisy and unsightly equipment being located on rooftops of commercial and institutional buildings, or between houses in residential applications. The only drawback for this technology is the need for sufficient land in which to install the ground heat exchanger. It was reported that in some projects, vertical loops have been installed underneath buildings at the time of foundation work, simply because there was insufficient land area surrounding the building project. Initial costs may also present a barrier for adopting this technology, however, there now exist a wide variety of incentive programs to help defray these financial impacts. Despite these limitations, and assuming a source of clean electrical energy, geothermal heat pumps are an environmentally responsible and cost effective urban site technology that should be considered in new building developments.

Geothermal heat pumps are the most cost-effective option to provide space heating and cooling in Ontario. The implementation of geothermal heat pumps is a key strategy to displace electricity use and fossil fuels currently used for heating and cooling in residential and institutional/commercial buildings. By displacing electricity use and fossil fuels, the technology represents a very cost-effective greenhouse gas mitigation strategy. Geothermal heat pumps can be used across the province and are especially attractive for new buildings.

Smart Generation: Powering Ontario With Renewable Energy. The David Suzuki Foundation, 2004. http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

Figure 39. Geothermal heat pump technology can improve the urban environment by reducing sources of noise, pollution and unsightly equipment. As urban areas intensify, the aesthetics of rooftops gain importance.
[Photo: David Ross.]

Wind Energy
Unlike solar energy production, which relies on a favourable solar orientation along with adequate exposure and collector area, the production of wind energy requires a windy location that is not affected by surrounding buildings and terrain. For this reason, the potential for significant wind energy generation within most building developments is limited in the Greater Toronto Area (GTA) and most of the Golden Horseshoe (GGH).

This does not mean that wind power is not feasible for new building developments, but that it in most cases, it will be generated in remote locations and the electrical energy transferred to the new development through the existing electrical energy grid. Figure 40 depicts the wind power potential in southern Ontario and it indicates that most of the GGH land area hold marginal potential. Surrounding land areas to the north-east and north-west of Toronto range from acceptable to very good wind energy potentials. The shorelines of Lake Ontario and further out into the lake hold the best potential. The same phenomenon is evident for Lake Erie, Lake Huron and Georgian Bay.

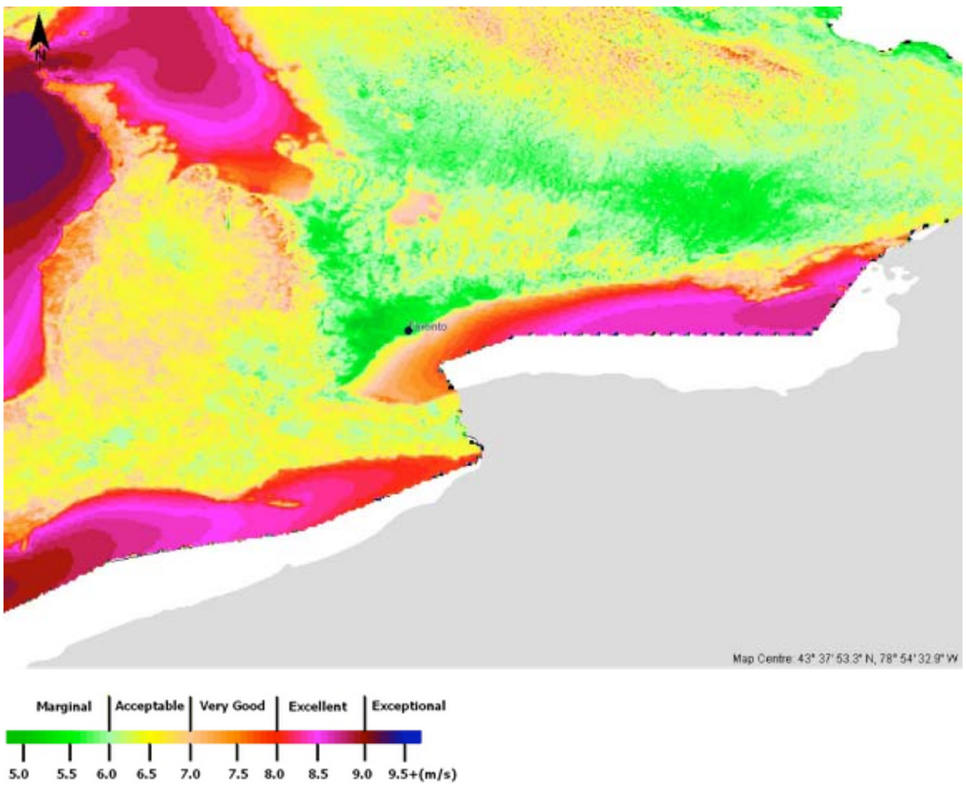


Figure 40. Greater Golden Horseshoe wind energy potential.
[Source: http://www.ontariowindatlas.ca/]

The potential contribution of wind power to Ontario's energy mix is significant and there are numerous benefits associated with the use of wind power to displace "dirtier" sources of electricity.

Wind is the fastest growing source of energy in the world, but Ontario is lagging behind. There is great potential for large-scale wind power generation in the province.

The technically achievable wind resource in Southern Ontario is 86 terawatts-hour (TWh) annually, or about 58% of current provincial consumption.

Based on European experience, especially that of Germany and Spain, Ontario could install as much as 8,000 MW of wind-generating capacity by 2012. A fleet of wind turbines representing an installed capacity of 8,000 MW could generate 14 TWh annually, or about 10% of current consumption.

Using the same assumptions as a recent economic impact study of Quebec's 1,000 MW tender for wind-generating capacity, 8,000 MW of wind capacity installed in Ontario could produce nearly $14 billion in economic activity and 97,000 person-years of employment.[72]

Figure 41. 750 kW wind turbine at Canadian National Exhibition site in Toronto.

This wind turbine was inspired by a group of Toronto residents who had a dream of cleaner energy and cleaner air. Their vision came alive through a joint venture partnership of Toronto Hydro Energy Services and the WindShare Co-operative, who jointly constructed the wind turbine on December 18, 2002. The turbine is a good example of how communities can work together to meet their electricity needs and address global issues of air pollution and climate change. This is the first wind turbine erected in the City of Toronto and the first in a downtown urban setting in North America. It stands thirty stories tall and has the capacity to power up to 250 homes. Electricity from the wind yields no emissions, no waste, and is 100% green.
[Photo and commentary courtesy: Toronto Hydro. Refer to commentary on next page.]

[72] *Smart Generation: Powering Ontario With Renewable Energy*. The David Suzuki Foundation, 2004.
http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

The City of Toronto remains a strong advocate of wind power and has identified suggested actions to promote wind energy. The biggest barriers to wind energy are environmental and political. Establishing large wind farms along the shores of Lake Ontario or out in the water is questioned by environmentalists and residents alike. Ducted turbines located on the tops of buildings are viewed by many as preferable locations for urban installations.

In 2003 the first urban-sited large (750 kW) wind turbine in North America was installed in downtown Toronto on the grounds of Exhibition Place. The installation of this turbine was inspired by the Toronto Renewable Energy Co-op (TREC), a local community group that followed the wind community co-op model developed successfully in Denmark. This project created many North American "firsts" – including the first turbine owned jointly by a publicly owned electricity company (Toronto Hydro) and a community based co-operative, and it helped spawn the creation of similar community energy groups in other cities and towns throughout Ontario.

The decisions that City Council rendered in allowing the installation of the Exhibition Place wind turbine were landmarks for the wind energy in North America and have been used as municipal models by many other municipalities in Canada and the US. However, while Toronto was the first community to accept a large wind turbine in an urban setting in North America, there are currently no clear regulations outlining the use of wind turbines in Toronto.

Suggestion for Action

Toronto should, in consultation with various stakeholders including the Canadian Wind Energy Association, develop regulations that facilitate the use of wind power in Toronto on public and privately owned spaces.

Wind power in Toronto is economical today. Construction costs are estimated to be lower than those for nuclear reactors. Operating costs are very low, and there are no issues with long term hazardous waste storage. In addition, winds tend to blow on winter evenings when winter demand peaks. The two limitations of wind energy in Toronto are availability of locations and intermittency of the resource. Toronto's greatest potential for capturing strong winds is along the lake. A 60 MW wind farm was being considered by Toronto Hydro in the lake near the Scarborough Bluffs; however the province has placed a freeze on all off-shore wind projects pending further study on their environmental impacts.

Suggestion for Action

Toronto should advocate for a speedy environmental assessment of wind power on the Great Lakes – the process to develop a review process on the environmental impact has not been outlined by the provincial government yet.

Additional potential exists on the land or water near the Toronto Islands and the Western Beaches. A consortium of private and community groups, "Spitting in the Wind", is looking at installing wind generators in this area. With sufficient support, it is estimated that an additional 20-50 MW of wind generation could be built within the few years, and that in the long term up to 200 MW could be installed in Toronto and offshore.

Wind generators require both high wind speeds and "laminar" wind flow to produce significant quantities of power – these are achieved in flat open spaces and high above the ground. For this reason smaller wind machines are generally not viable in urban settings and the potential of small residential wind turbines is considered small in Toronto.

However, there is growing international interest in the development of special wind generators specifically designed for the "urban form." These turbines are designed for the tops of high buildings and are expected to become popular in the future generations of high rise buildings that will be zero energy. While this is a technology that is largely undeveloped, Toronto should ensure that its local regulations do not unnecessarily prohibit this power source.[73]

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[73] *Energy Efficiency and Beyond: Toronto's Sustainable Energy Plan*. Staff Background Report, Energy Efficiency Office, Business & Strategic Innovation, Facilities & Real Estate Division, June 2007.
http://www.toronto.ca/legdocs/mmis/2007/pe/bgrd/backgroundfile-4989.pdf

Assuming these issues can be resolved, the general outlook for wind energy is positive as noted by the Conference Board of Canada:

The future of wind power is bright. Depending on the price levels of natural gas, wind energy may be cost-competitive against conventional generation without government subsidies. Under some general assumptions of $1000/kW capital cost, 90% capacity factor, and a heat rate of 7.5 MW/GJ, natural gas combined cycle generators need to recover an average of approximately 6.5 cents/kWh with $6/GJ gas. With $3 natural gas, this number falls to approximately 4.25 cents/kWh. Vision Quest WindElectric Inc. believes they can recover their return on investment with electricity prices between 6-6.5 cents/kWh. Achieving this return is primarily dependent on the wind farm's proximity to existing transmission infrastructure, wind conditions in the area, and sizing the farm at 75-150 MW to take advantage of economies of scale. Should one include the subsidy in this thinking, wind power can compete against approximately $4.60/GJ natural gas. One natural gas forecast published by Chenery Dobson Resource Management Inc. suggests $4/GJ as long-term (through 2016) price. This would seem to suggest that while technological advancements are reducing the cost of wind turbines by about 5% per year, the Wind Power Production Incentive will continue to be an effective program in the near-term to foster wind power growth in Canada. As evidence from Alberta suggests, with government subsidization wind power has the ability to attract sustained investment in a competitive marketplace. As more jurisdictions in Canada install wind generation, and wind technology improves, wind generation will become increasingly attractive.*[74]

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*The commitment of funds for wind energy projects under the WPPI program ended on March 31, 2007. This program has now been replaced by ecoENERGY for Renewable Power, whereby the federal government will invest $1.48 billion to increase Canada's supply of clean electricity from renewable sources such as wind, biomass, low-impact hydro, geothermal, solar photovoltaic and ocean energy. It will encourage the production of 14.3 terrawatt hours of new electricity from renewable energy sources, enough electricity to power about one million homes. ecoENERGY for Renewable Power will provide an incentive of one cent per kilowatt-hour for up to 10 years to eligible low-impact, renewable electricity projects constructed over the next four years, April 1, 2007 to March 31, 2011.
http://www.ecoaction.gc.ca/ecoenergy-ecoenergie/power-electricite/index-eng.cfm

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[74] *Renewable Energy in Canada*. Conference Board of Canada, September 24, 2003.
http://www.conferenceboard.ca/pdfs/Renewable_Energy_Canada.pdf

District Energy Systems

The economic, environmental and energy efficiency benefits associated with district energy systems are well understood in Canada, and much of the developed world. A brief history of this technology is summarized below:

The oldest district heating system was created in the early fourteenth century in Chaudes-Aigues Cantal - a village in France. This system distributed warm water through wooden pipes and it is still in use today. The first commercial district heating system was created by Birdsill Holly in Lockport, New York in 1877. Holly used the boiler as the central heat source and built a loop consisting of steam pipes, radiators, and even condensate return lines. His system started off with fourteen customers. Only 3 years later, it served several factories as well as residential customers and had extended to a 3-mile loop. District cooling also has its roots in the nineteenth century. It was introduced as a scheme to distribute clean, cool air to houses through underground pipes. The first known district cooling system began operations at Denver's Colorado Automatic Refrigerator Company in late 1889. In the 1930's, large district cooling systems were created for Rockefeller Centre in New York City and for the U.S. Capital Buildings in Washington, D.C.

The success of district energy systems throughout Europe led to the development of district energy in a number of Canadian communities. Historically, Canada has had the highest per capita energy use of developed countries. This is due to our severe climate and an abundance of relatively low-cost energy supplies. District energy is an attractive, more efficient and more environmentally friendly way to reduce energy consumption. It is believed that district energy in Canada began in London, Ontario in 1880. The London system was built in the form of group systems serving the university, hospital, and government complexes. University of Toronto is known to have developed a district heating system in 1911 that served the needs of the university. The first commercial district heating system in Canada was established in 1924, in the city of Winnipeg's commercial core. Canada boasts the site of one of the northernmost district energy systems in North America: Fort McPherson, located in the North West Territories. Originally owned by the North West Territories Power Corporation, Fort McPherson later became Addri Ltd. - a Gwich'in (First Nations) word roughly translated as "The Light."
[Source: District Energy Windsor http://www.wuc.on.ca/dew/history.cfm]

Rising energy costs and greenhouse gas emissions combined with concerns over sprawl and crumbling infrastructure, suggest that traditional approaches to community planning will not be enough to meet growing energy needs now or in the future. Already accepted as the "gold standard" in Europe, integrated energy planning allows communities to accept responsibility for shaping urban form, directing conservation efforts and finding new partners to deliver energy. Communities across Canada are now beginning to take a more active role in managing their energy demands and are recognizing the potential of "energy" as a key contributor to long-range planning. "Factor-2" communities harness the power of district energy and other energy focused strategies to promote compact urban form, extend the life of urban infrastructure, and reduce the reliance on fossil fuels. As the effects of climate change begin to be detected in urban regions across Canada, communities are looking for strategies to improve community infrastructure resiliency and adaptability. Integrated energy planning provides an opportunity to take a closer look at just how a community might adapt essential energy services.
Canadian Institute of Planners, 2007 Conference Notes. http://www.cip-icu.ca/2007conference/presentations%20for%20conference/UD13_summary.pdf

Most district energy systems involve the use of co-generation technology, also referred to as combined heat and power (CHP) systems. This technology involves the simultaneous production of electrical and thermal (heat) energy from a single fuel. By making use of the heat rejected from one process (electricity generation) in the production of the other (heat generation), significant gains in energy efficiency are possible compared to the independent generation of electricity and heat. Some advanced systems employ tri-generation, where the waste heat from co-generation is fed into absorption chillers that produce chilled water for cooling purposes. The tri-generation process produces four different forms of energy from the primary energy source, namely, hot water, steam, cooling (chilled water) and power generation (electrical energy). Tri-generation has also been referred to as CHCP (combined heating, cooling and power generation).
http://www.cogeneration.net/Trigeneration.htm

The benefits of district energy systems have been summarized by the International District Energy Association (IDEA) as follows:

- ***Environmentally sound****. District energy enables building owners and managers to conserve energy, improve operating efficiency and protect the environment. With district energy, building managers no longer need to burn fuels or store or use refrigerants on site, so the site is safer and more environmentally sound - and does not need unsightly smokestacks. Instead, fuel and refrigerants are used at district energy plants. These systems employ stringent emission controls - more so than individual buildings - and this provides air-quality benefits.*
- ***Easy to operate and maintain****. District energy is worry-free heating and/or cooling delivered directly to a customer's building - ready to use. Customers do not need boilers or chillers, so there is less maintenance, monitoring and equipment permitting. And that allows occupants, rather than energy operations, to be the focus. District energy customers also eliminate the need for fuel deliveries, handling and storage so there are fewer safety and liability concerns for employees and building occupants.*
- ***Reliable****. Building owners and managers can count on district energy systems since energy professionals operate around-the-clock and have backup systems readily available. Most district energy systems operate at a reliability of "five nines" (99.999 percent).*
- ***Comfortable and convenient****. District energy service allows building operators to manage and control their own indoor environments. Building occupants can be both comfortable and satisfied, no matter what the outdoor temperature. District energy is available whenever a building needs heating or cooling. So even if there are unusually warm days in January, a building can receive chilled water or steam for air conditioning, without starting up its own chillers. In addition, district energy reduces vibrations and noise problems that could annoy building occupants and frees up building space so more room is available to meet increasing tenant storage needs.*
- ***Lower life-cycle costs****. Since buildings using district energy service don't need boilers or chillers, building owners and managers reduce their upfront capital requirements and their ongoing, operating, maintenance and labor costs considerably. That means less financial risk and a far better return on investment - plus the elimination of principal and interest payments, property taxes associated with new boiler and chiller installations, costly insurance and annual maintenance contracts, and costs associated with operating boilers and chillers. In addition, district energy systems have the flexibility to use a variety of fuel sources in larger, more economical volumes - from oil to natural gas to coal to biomass - reducing the impact of supply and price variations.*
- ***Design flexibility.*** *No smoke stacks, boilers or cooling towers means greater building design flexibility. Architects can easily design or renovate buildings to be more versatile and aesthetically pleasing for both potential occupants and the community.*

[Source: International District Energy Association http://www.districtenergy.org/benefits.htm]

District energy systems are not a new urban site technology, but they do offer a reliable means of introducing new forms of energy generation that rely less on non-renewable fossil fuels and begin to explore renewable energy forms like bio-fuels coupled to clean storage technologies such as fuel cells. The cost effectiveness of district energy systems and their contributions to environmentally responsible energy production can now be better assessed in the community development process.[75]

Full Financial Quantification of Long Term Benefits

Economic feasibility often dismisses several of the tangible benefits of distributed CHP, including:

1. Avoided costs of replacing aging utility, industrial, and commercial boilers, and long power transmission lines;
2. The impending phase out costs of CFC chillers;
3. The energy security provided by local power and district energy loops; and
4. The prevention of all air emissions, and cooling water impacts.

On the last point, it may be usual to quantify the monetary impact on GHGs, without also adding the common reductions in regional acid rain, smog and air toxic emissions, plus less cooling water usage. Certainly, clean-fueled CHP can provide all of those benefits, and portions of capital and operating costs should be allocated to each emission reduction to show multi-pollutant $/tonne cost-effectiveness. The ability to carry out financial analyses that are robust in the long term is also a hindrance. Short term planning and fast paybacks may not provide good solutions. Societal infrastructure, such energy and transportation, must be viewed as a long term investment for our children.

A Look at Combined Heat and Power Energy Systems In Canada. Manfred Klein, Electricity Today, Issue 6, 2003, pp. 33-35. http://www.electricity-today.com/et/issue0603/combined_heat.pdf

[75] *The New District Energy: Building Blocks for Sustainable Community Development*. Online Handbook, Urban Energy Solutions Initiative, January 2008. www.toronto.ca/taf/pdf/ues_handbook.pdf

TRIGENERATION SYSTEM

TORONTO, ON - One of the largest trigeneration systems in Canada and the first that is municipally-owned has opened at Toronto's Exhibition Place. The $4.4 million trigeneration system is supported by a Green Municipal Fund loan of $1,075,000, a $1 million loan from the Toronto Atmospheric Fund and $2,325,000 from the City of Toronto's Energy Retrofit Program. It will become the sole source of power, heat and provide most of the cooling for the Direct Energy Centre at Exhibition Place. The system consists of one 1,600 kilowatt natural gas-fired generator with a heat-recovery package and a hotwater driven absorption chiller. The waste heat produced by the engine is recovered and supplied in the form of hot water to the absorption chiller, which in turn provides cooling through a chemical process for the Direct Energy Centre in the summer and augments the heating boilers in the winter. The recovered heat improves overall plant efficiency from 40%, which is typical of a standard engine, to an 80% level. "We estimate that Exhibition Place's trigeneration system will produce an estimated 12 million kilowatt-hours of electricity per year; displace 7,400 tonnes of carbon dioxide (CO2) emissions; and supply approximately 30% of the energy needs of Exhibition Place," says City of Toronto Deputy Mayor Joe Pantalone, chair of the board of governors of Exhibition Place.

Report on Industry, Spring 2007.
http://www.roimagazine.com/Archives/Spr_07_ENV.pdf

Combined Heat and Power

The issues relating to the cost effectiveness of co-generation or combined heat and power systems are complex. Some case studies are indicative of the technology's potential application in new developments. Combined heat and emergency power systems (CHeP) have been introduced into a number of Toronto's multi-unit residential buildings and building complexes. Replacing diesel generators for emergency power supply with co-generation systems provides better survivability in buildings because both heat and electricity are generated simultaneously.[76]

Cogeneration, also referred to as combined heat and power (CHP), is the simultaneous production of electrical and thermal energy from a single fuel. By making use of the heat rejected from one process in the production of the other, substantial gains in energy efficiency are realized compared to the independent production of both products. Cogeneration represents just over 6% of national electricity production in Canada. This relatively low penetration (compared to Europe) is attributed to Canada's historically low energy prices and electric utility policies on the provision of back-up power and the sale of surplus electricity.

If we assume that all heat loads in industrial, commercial / institutional and residential sectors can be met with cogeneration technologies that have low heat to power ratios (2:1 in industry and 0.9:1 in the other sectors), one could generate enough to supply about 80% of Canada's electricity demand. If we take a more realistic approach, cogeneration could provide 30% of Canada's current electricity needs.

Finally, a number of benefits exist which are not internalized into economic calculations. Were these to be included in any analysis of the economic potential of cogeneration, one would see an improvement of the economic factors. These unaccounted for benefits include:

- *conservation of energy as a resource*
- *international issues regarding supply of energy*
- *energy security and "ice storm" type incidents*
- *benefits of distributed generation and its role in energy security*
- *reductions of all types of emissions*
- *avoid transmission expenditures and losses to the grid*

The environmental and economic benefits are clear: co-generation results in fuel savings of 30-40%; co-generation reduces greenhouse gas emissions by two thirds; other pollutants are also reduced, such as sulphur, nitrogen, particulate matter.[77]

CHP potential in Canada is very high and the technology has many acknowledged benefits, but it requires a concentration of buildings and sufficient population density to make use of the heat generation. It must be assessed in the context of a large mixed-use building complex or an integrated community based energy system. From the perspective of a green development agenda, combined heat and power systems represent an opportunity to utilize renewable bio-fuels to displace non-renewable energy sources at a scale that is suited to the demands of not only residential developments, but also industrial, commercial and institutional customers.

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[76] *Towers of Power: Advancing Combined Heat and Power in Multi-Residential Buildings*. Ontario Clean Air Alliance, March 2007.
www.cleanairalliance.org/resource/chpmultires.pdf

[77] *Cogeneration Potential in Canada: Phase 2.* Completed for Natural Resources Canada, by Catherine Strickland and John Nyboer of MK Jaccard and Associates, April 2002.
http://www.cieedac.sfu.ca/CIEEDACweb/mod.php?mod=pub&op=user&menu=1601

Bio-Fuels: Biomass and Biogas

Before the discovery of coal and petroleum products, the world relied on bio-fuels, mostly in the form of wood. Today, modern urban dwellers are surrounded by potential bio-fuels, but non-renewable energy suppliers dominate the marketplace. The urban sources of bio-fuels are: food industry; waste wood; biodegradable municipal solid waste; landfill gas; and sewage gas. Each of these sources represents a potential renewable energy generation opportunity. Renewable because the carbon dioxide released in the combustion of bio-fuels goes back into new plant growth, completing a closed carbon loop that is sustainable – assuming responsible environmental stewardship of food production and forest management.

This section of the report will not examine bio-fuels used for transportation purposes, but their potential is worth noting. "*Biofuels are fuels made from biological products. Two examples are ethanol and biodiesel. Ethanol is a commercial alcohol that is made today from grain. It can also be made from cellulose fibres such as straw, but this is a new approach and is still under development. Taking all factors into account during its production and use, ethanol from grain has about 40 percent fewer GHG emissions than gasoline, and cellulosic ethanol has about 80 percent fewer emissions than gasoline. Ethanol can be blended up to 10 percent with gasoline and used in cars without modifications. Biodiesel is a diesel fuel substitute that can be made from variety of vegetable oils and animal fats (e.g., recycled cooking greases). It can be blended with diesel, resulting in lower GHG emissions*."
[Source: Canadian Renewable Fuels Association http://www.greenfuels.org/]

In urban settings, landfill gas and biogas produced from food industry waste and source separated organics have significant potential for renewable energy generation. The harvesting of biogas is an important role of waste management because methane is a greenhouse gas with a greater global warming potential than carbon dioxide. Landfill gas can be burned to produce electricity, usually with a reciprocating engine or micro-turbine. The gas is commonly used in a cogeneration arrangement, to generate electricity and heat. Electricity produced by landfill gas is considered to be green power.

BIOMASS
Ontario can develop 2,450 MW of power generation using a variety of biomass sources, which can generate 14.7 TWh per year, provide a new source of income for the province's forestry and agricultural sectors, and help deal effectively with their residues. In addition to electricity generation, biomass sources can generate 114 petajoules (PJ) of green heat that can be used to displace electricity and fossil fuels currently used for residential and commercial space heating.
Smart Generation: Powering Ontario With Renewable Energy. The David Suzuki Foundation, 2004.
http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

Figure 42. Converting landfill gas to electricity reduces greenhouse gas emissions and conserves non-renewable energy resources. [Photo courtesy City of Ontario, California.]

Another upcoming form of renewable energy is biogas from source separated organics (SSO). The City of Toronto has taken the initiative to process SSO using anaerobic digestion to obtain biogas that can fuel combined heat and power technology. By 2011, it is anticipated two facilities will be fully operational to process all of the SSO from the City's composting program. The by-product of the anaerobic digestion is a digestate that is suitable for agricultural purposes. In its own cost-benefit assessment, the City of Toronto concluded:

Comparing best alternatives with and without anaerobic digestion concluded that anaerobic digestion offers a positive net benefit. An important benefit of anaerobic digestion is the ability to generate renewable energy in excess of the requirements of facility operations. Based on the performance of the anaerobic digestion operation at the Dufferin organics processing facility, it is estimated that the anaerobic digestion of 110,000 tonnes per year of SSO [source separated organics] could produce approximately 17,640 MWh/yr of electricity in excess of plant operating requirements, equal to the annual electricity consumption of approximately 1,700 homes.[78]

Figure 43. Anaerobic digester at Dufferin Organic Processing Facility, North York. [Photo courtesy City of Toronto]

Figure 44. Biogas conversion into pipeline quality natural gas (methane) is a high technology industry that has the potential to create research expertise and new manufacturing jobs in Ontario. [Photo courtesy Cirmac, Sweden]

[78] *Recommendations of the Planning Study for Expanded Public Source Separated Organics (SSO) Processing Capacity*. City of Toronto Solid Waste Management Services, May 16, 2007. http://www.toronto.ca/legdocs/mmis/2007/pw/bgrd/backgroundfile-3867.pdf

Municipalities are not the only investors in biogas cogeneration technology. A recent announcement signaled the beginning of a new renewable energy frontier that is emerging wherever people generate large quantities of organic waste.

STORMFISHER BIOGAS AND DENHAM CAPITAL MANAGEMENT ANNOUNCE $350 MILLION PARTNERSHIP TO DEVELOP BIOGAS-BASED RENEWABLE ENERGY PROJECTS

Projects Create Needed Energy from Food By-Products, Cutting Greenhouse Gas Emissions

TORONTO - February 14, 2008 - *StormFisher Biogas announced today that it has formed a strategic partnership with Denham Capital Management, a Boston-based private equity firm, to develop a Cdn$350 million portfolio of biogas projects. StormFisher believes that this is the largest dedication of capital to a biogas-focused renewable energy platform to-date. The partnership is projected to bring about a reduction of greenhouse gases equivalent to removing approximately 26,000 average-sized cars from the road.*

Bas van Berkel, StormFisher's President, said the firm will seek biogas projects, at any stage of development, across North America, and will consider acquisitions as well. "We have aligned ourselves with Denham because of its commercial experience and clear understanding of our business model, including the carbon element. Our relationship with Denham makes us one of the most well-funded biogas companies in the world," he said. In North America today, the majority of food by-products are disposed of either in compost sites or landfills, where they become major contributors to greenhouse gas emissions. Converting these organic by-products into biogas through anaerobic digestion is an environmentally-friendly way of producing needed forms of energy, and an ideal way for food processing companies to cut costs and improve environmental stewardship. As confirmed recently in a Swiss study, biogas from food processing and agricultural by-products is one of the most sustainable forms of renewable energy production.

"In Europe, biogas installations are widespread, with about 5,000 in operation," said StormFisher Vice President of Business Development, Ryan Little. "As we become more environmentally and energy conscious in North America, biogas is a clear choice for addressing these issues." StormFisher intends to develop a portfolio of about 30 biogas projects across North America over the next five years. Power projects are expected to be between two and five megawatts in size, while natural gas projects are expected to deliver between 150,000 and 350,000 MMBtu per year of pipeline quality natural gas. This portfolio would generate enough energy to power roughly 75,000 homes, reduce greenhouse gases by an estimated 1 million tonnes of CO_2 equivalent and keep more than 6 million tonnes of organic by-products out of disposal sites, among a number of other positive environmental and societal benefits.

StormFisher's first three development projects, which are all located in Ontario, Canada, will break ground in late 2008 and be operational by Fall 2009. "Ontarians are determined to do their part in reducing greenhouse gas emissions and fighting climate change," said Ontario Premier Dalton McGuinty. "These projects will contribute to a greener province and put our economy at the leading edge of energy innovation."

[Source: StormFisher Biogas Press Release, February 14, 2008.]

> *TORONTO'S GREENHOUSE GAS AND SMOG EMISSION REDUCTION TARGETS*
> *Toronto's reduction targets for greenhouse gas emissions, from the 1990 levels of approximately 22 million tonnes per year for the Toronto urban area, are:*
> - *6% by 2012 (The "Kyoto Target")*
> - *30% by 2020*
> - *80% by 2050*
>
> *The reduction target for locally generated smog causing pollutants is 20%, from 2004 levels, by 2012 for the Toronto urban area.*
>
> ***Change is in the Air*** – Climate Change, Clean Air and Sustainable Energy Action Plan: Moving from Framework to Action, Phase 1, Highlights. City of Toronto, June 2007. http://www.toronto.ca/changeisintheair/pdf/clean_air_action_plan.pdf

Renewable Energy Market

The cost effectiveness of renewable energy is often cited as a deterrent to its broader implementation. It is acknowledged there are numerous environmental benefits and there are even programs in Ontario to ease the adoption of renewable energy, but often the technology represents a prohibitive initial cost and lengthy payback period. However, this common perception is being challenged by rapidly rising fossil fuel prices and a public interest to more fully account for the externalities and subsidies associated with conventional energy production. There has been a shift in the Ontario renewable energy market, and there are several technologies that show great promise of being cost competitive today.

Renewable Energy Standard Offer Program

A major influence in Ontario's renewable energy market is the Ontario Power Authority's Standard Offer Program. It makes it easier for operators of small renewable energy generating facilities to participate in Ontario's electricity supply system by supplying power through their local electricity distributors and being paid a fair and stable price for the power they provide. From a planning perspective, operators are urged to investigate all of the implications of running their operations, including determining a business structure, paying business income taxes, and tracking costs and revenues. Projects currently entering into contracts with the Ontario Power Authority can range from residential photovoltaic rooftop generation of 1 kilowatt (costing about $12,000) up to small wind farms of 10 megawatts (costing about $25 million).[79]

Period	**Wind**		**Solar PV**		**Water Power**		**Bio-Energy**		**Total**	
	#	**Capacity**	**#**	**Capacity**	**#**	**Capacity**	**#**	**Capacity**	**#**	**Capacity**
2007	65	569,527	145	252,140	14	31,829	17	58,178	**241**	**911,674**
2008										
January	4	29,905	13	64,351	1	10,000	3	8,700	**21**	**112.956**
February	7	55,8020	6	24	4	24,250	0	0	**17**	**80.076**
To date	***76***	***655,234***	***164***	***316,515***	***19***	***66,079***	***20***	***66,878***	**279**	**1,104,706**

Table 31. Summary of Renewable Energy Standard Offer Program (RESOP) contracts executed up to February 2008 (rounded to nearest kW).[80]

Table 31 indicates that since its inception, the Standard Offer Program has executed contracts totaling about 1.1 million kilowatts. Only about 34,147 kW of capacity are in commercial operation as of February 2008. Having only 3% of the executed contracts operational indicates there is considerable time involved with arranging financing and construction/commissioning renewable energy technologies. Some industry experts have suggested the part of the delay may also be attributable to economic considerations since prices for renewable energy technologies are rapidly declining as they become more broadly implemented on a global scale.

[79] *Ontario Standard Offer Program*. Ontario Power Authority. http://www.powerauthority.on.ca/sop

[80] *A Progress Report on Renewable Energy Standard Offer Program*. Ontario Power Authority, February 2008. http://www.powerauthority.on.ca/SOP/Storage/66/6199_RESOP_February_2008_report.pdf

Renewable Energy In Canada

A recent study prepared by CIEEDAC for Natural Resources Canada and Environment Canada provided a review of renewable energy in Canada from 1990 to 2004.[81]

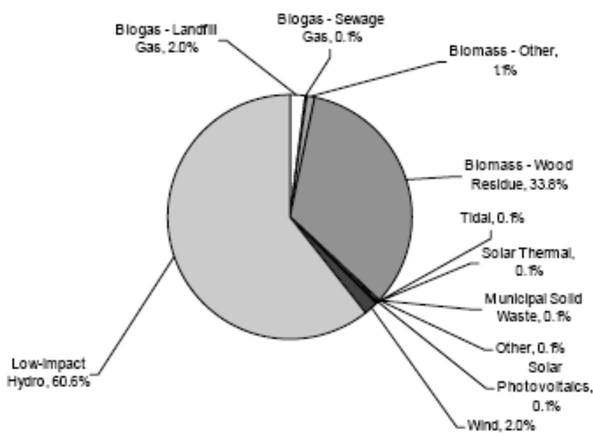
Renewable energy was estimated to provide 14% of Canada's energy supply in the year 2004, and 76% of its electricity. The installed renewable energy capacity of 78 gigawatts is dominated by conventional hydroelectricity, low-impact hydro, and biomass, accounting for 72%, 17% and 10% of the total respectively, with hydro, wind, biogas, and solar photovoltaic sources, accounting for around 1% of Canada's installed capacity. This adds up to a displacement of about 138 million tonnes of CO_2 equivalent. The majority of Canada's renewable energy capacity is owned by integrated electric utilities.

Renewable energy capacity was added rapidly throughout the century. There has been an increasing emphasis on lower impact energy sources, but the overall percentage remains small.

There is a high rate (51%) of eco-certification among wind facilities. Approximately 20% of run-of river hydro facilities are eco-certified with a lower rate of 15% for all hydro.

Respondents held a variety of viewpoints about policy, but a common suggestion was an increase in financial incentives and a decrease in the regulatory burden for providers of renewable energy.

The three figures which follow are excerpted from the above noted CIEEDAC report. Figure 45 indicates that in 2004 low-impact hydro was the dominant form of renewable energy in Canada (60.6%), followed by biomass (33.8%), then biogas (2%) and wind (2%). The remaining sources of renewable energy are relatively negligible.



Source: CIEEDAC Renewable Energy Database, 2004

Figure 45. Total renewable energy capacity (%) by resource type, excluding conventional hydro.

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[81] A Review of Renewable Energy in Canada, 1990 – 2004. Prepared for: Natural Resources Canada and Environment Canada. Canadian Industrial Energy End-use Data and Analysis Centre, Simon Fraser University, Burnaby, BC, February, 2006. http://www.cieedac.sfu.ca/CIEEDACweb/mod.php?mod=pub&op=user&menu=1601

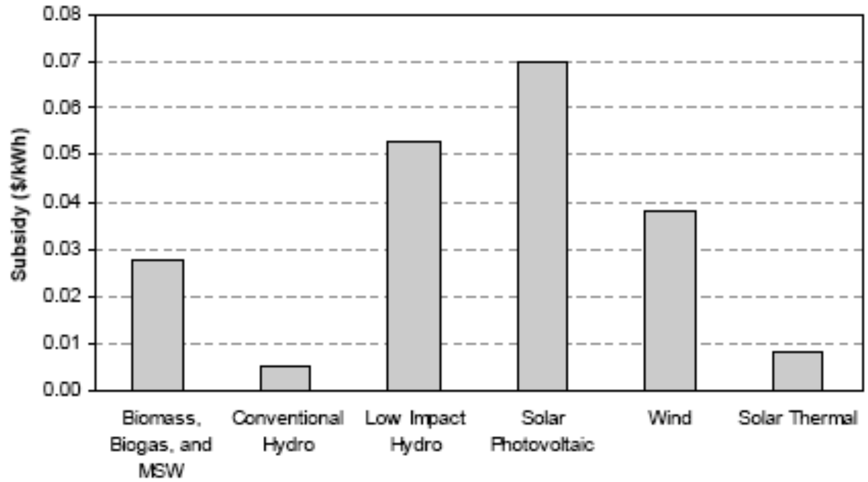
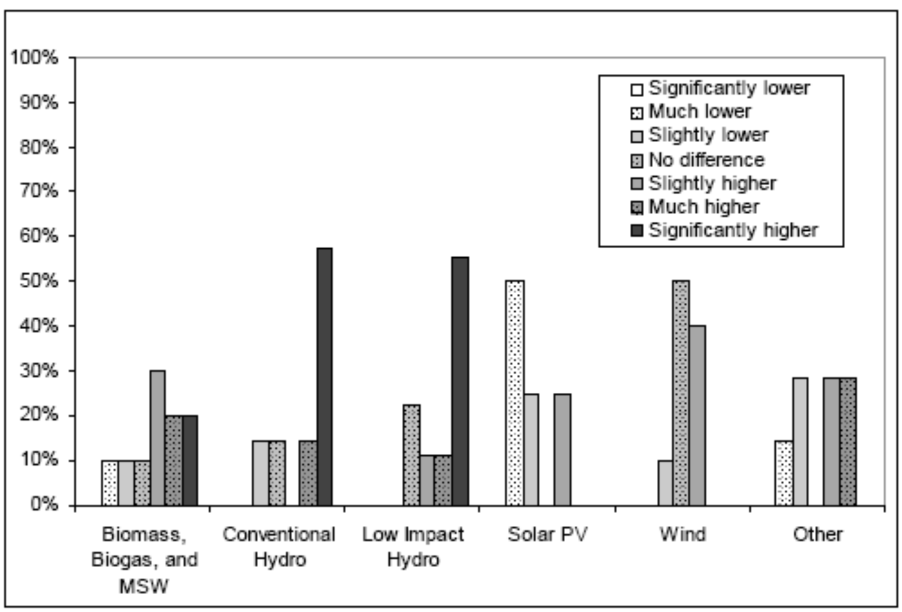


Figure 46. Required subsidy by resource type. [Source: CIEEDAC 2006.]

A number of participants in the study were interviewed to determine the level of subsidy needed to render their renewable energy resource cost competitive. An interesting comparison may be noted between conventional and low-impact hydro, with the latter requiring about ten times the level of subsidy. Solar thermal was found to require the lowest level of subsidy after conventional hydro, whereas solar photovoltaic required some 7 cents per kilowatt-hour of subsidy.

Figure 47 summarizes the responses to the following question: "*If you were to start from scratch and re-install the same facility again starting today, would the cost be lower, either due to your previous experience or due to general cost trends for equipment?*"



Source: CIEEDAC Renewable Energy Database, 2004.

Figure 47. Expected costs of installation today.

The generally observed trend is that energy sources with associated environmental risks reported similar or higher reported costs, while environmentally benign technologies were expected to have generally lower installed costs.

Barriers and Opportunities

The cost effectiveness of renewable energy technologies is no longer a disputable point in many countries of the world. In Canada, an abundance of non-renewable energy resources and a relatively high level of affluence have delayed collective commitment. The following excerpt from the Washington Renewable Energy Conference offers insights on the Canadian context.

From March 3-6, 2008 ministers from around the globe along with 9000 other delegates met in Washington to discuss ways of scaling up renewable energy. At the Washington Renewable Energy Conference (WIREC) – the largest renewable energy conference ever held - each country was asked to make major new policy commitments that will support new investment in renewable energy technology. A parallel renewable energy business conference and trade show illustrated the latest renewable energy technologies and global market that have risen to over $100 billion per year. Investors love the low risk, fast pay back from renewable energy projects which can be installed quickly and do not depend on future fuel prices. Key conclusions from WIREC included:

- *Deployment of renewable energy is expanding globally much faster than expected, with 2007 investments topping $100 billion.*
- *Renewable energy technology can be deployed quickly and reduce greenhouse gases immediately, while alternatives like nuclear and carbon capture will take a decade.*
- *It is not the lack of capital that is holding renewable energy back. Investors are flocking to the sector because of its low risk relative to energy sources that depend on fuel prices or have long term waste problems.*
- *Long term stable policies and price signals are imperative for any significant renewable energy market to evolve.*
- *The most effective long term policy for the power and heat sectors is the guaranteed fixed price/priority grid access feed-in tariff policy.*
- *The food versus fuel land use concerns about bio-fuels are real but can be managed through enforcement of strict criteria and regulations.*

Significant Pledges made at the conference included:

- *Denmark: At least 30% renewable energy, 15% reduction in fossil fuel use, and 1.4 % energy efficiency per year, all by 2025.*
- *Germany: New laws to support renewable heat, 20-30% renewable power by 2020, 10% biogas by 2030, and financing for developing countries.*
- *New Zealand: 90% renewable electricity by 2025.*
- *United States: $10 billion in loan guarantees, making solar electricity competitive by 2015, 36 million gallons of bio-fuels by 2022, $2 billion to new developing country clean energy trust fund.*

The Canadian Renewable Energy Alliance (CanREA) called on Canada to announce new or strengthened renewable energy polices at the conference. Yet Canada did not even send a minister to WIREC and made no new pledges to support renewable energy, relying instead on listing existing programs. Canada is lagging behind the rest of the world on the use of renewable energy, yet it has more renewable energy resources than most other countries. The lack of a strong Canadian commitment to renewable energy is a huge lost opportunity. We are missing out on the fastest growing energy source of the 21st century and one of the best ways to tackle global warming. Instead Canada chooses to support unreliable and environmentally problematic technologies like nuclear energy as well as unproven technologies like carbon capture and storage.[82]

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[82] *Washington International Renewable Energy Conference (WIREC)*, March 4-6, 2008 Washington DC. Draft Report by Roger Peters, the Pembina Institute http://pubs.pembina.org/reports/WIREC-conference-summary.pdf

Feed-in tariffs have consistently demonstrated that they are, to date, the most effective mechanism to stimulate a rapid, sustained and diverse deployment of renewable energy.

Feeding the Grid Renewably Fact Sheet. Pembina Institute. http://pubs.pembina.org/reports/FITariffs-factsheet.pdf

Using Feed-In Tariffs to Capitalize on Renewable Energy Primer. Pembina Institute February 2008.
http://pubs.pembina.org/reports/FITariffs_Primer.pdf

> *"Feed-in tariffs have consistently demonstrated that they are, to date, the most effective mechanism to stimulate a rapid, sustained and diverse deployment of renewable energy."*
>
> ***Feeding the Grid Renewably Fact Sheet***. Pembina Institute. http://pubs.pembina.org/reports/FITariffs-factsheet.pdf

New Energy Finance (http://www.newenergyfinance.com) has summarized the policies needed to maximize investment in energy efficiency and renewable energy:[83]

- *General macro-economics for innovation & entrepreneurship*
- *Taxation / bureaucracy / labour laws*
- *Intellectual property transfer from universities*
- *Legislative stability*

Ensure access to markets for clean energy providers:

- *Reduce/remove taxation on clean products & services (fuel tax, stamp duty, sales tax etc)*
- *Remove regulatory/legislative barriers (building codes, energy markets etc)*
- *Establish clear standards (ISO, DIN, TUV etc)*
- *Reduce subsidies for non-clean energy*
- *Net/smart metering*

Use public sector to create markets, not to pick winners:

- *Public procurement*
- *Consumer & business education*

Decouple incentive programs from social/political goals:

- *Limited, targeted, professionally-run funds*
- *Design grant programs around start-ups*

[83] Excerpted from *Financing Sources and Mechanisms for Renewable Energy and Energy Efficiency*. Canadian Renewable Energy Alliance, August 2006. http://www.canrea.ca/pdf/CanREAFinancingPaper.pdf

Green Power

Currently, there is one major green electricity retailer serving the Ontario market – Bullfrog Power. Founded in 2005, Bullfrog Power currently services Ontario and Alberta residents and businesses. Bullfrog purchases power from clean, green generators that harness wind power and low-impact water power. Each of the generators are certified by EcoLogo™ Environment Canada's Environmental Choice Program. The power source mix is approximately 80% certified low-impact hydro and 20% wind energy.

Customers have their green power delivered through the current electrical energy transmission and distribution system, and these various charges are added to cost of energy billed through Bullfrog Power. As of the time of this report, Bullfrog Power costs 8.9 cents per kilowatt hour (about 3.5 cents more than conventional power sources), which for the average Ontario homeowner adds about $1 a day to the electricity bill. The retailer is audited to ensure sales of green power do not exceed the actual production capacity. Additional information is available at: http://www.bullfrogpower.com.

Green Energy Certificates[84]

Ontario Power Generation (OPG) offers Green Power through its Evergreen Green Power marketing program for large commercial/industrial customers. The Green Power facilities are all EcoLogo-certified. The program was launched in 2001, and at the end of 2004, seven commercial/industrial customers were participating. Interest among individual buyers has waned due to Ontario's ambitious policies to increase Green Power content for all customers in the province's portfolio. The program is not offered directly to residential customers but they can participate through resellers. The only reseller is Oakville Hydro. OPG's Green Power portfolio consists of energy provided by 29 small hydro plants as well as some wind, biogas and solar sources. Three products are offered through the Evergreen Green Power Program:

- *"Evergreen Friendly Power," generated entirely from facilities built prior to 1991;*
- *"Evergreen Clean Green Power," a 50/50 blend of power generated from facilities built both prior to 1991 and after 1990;*
- *"Evergreen Pure Green Power," generated entirely from facilities built after 1990.*

The three products are offered at an average price premium of $35/MWh, with prices customized depending on the size of the customer and the timing of the purchase. Evergreen Friendly Power is offered exclusively to resellers and is intended to be blended with power generated by facilities built after 1990 (this is necessary to meet EcoLogo certification criteria that require Green Power products to incorporate a minimum 50% of power from facilities that began operations in 1991 or later). The other two products are EcoLogo-certified.
http://www.opg.com/safety/sustainable/evergreen.asp

Oakville Hydro created the Green Light Pact program in 2003 to provide Green Power to residential and small business customers. The power is Evergreen Clean Green Power purchased from Ontario Power Generation (see above) and all generating stations are EcoLogo-certified. The Green Light Pact program can be considered a certificate marketing program since anyone in Ontario, and not necessarily electricity consumers, can purchase a "Green Light Pact." The Pacts (environmental attributes) are sold in 500 kWh blocks for $30 or 1,000 kWh blocks for $60. http://www.oakvillehydro.com/greenpower_residential.asp

[84] *A Consumer Guide to Green Power in Ontario*. Pollution Probe. http://www.pollutionprobe.org/whatwedo/greenpower/consumerguide/ontario.htm

> *"Financing renewable energy systems can therefore be seen as the most important tool to overcome market barriers, combined with other measures, such as public awareness campaigns, training of the workforce, and the creation of rules and standards for the installation and interconnection of renewable energy systems. Especially small-scale renewables require three types of mechanisms at the same time: legislation, incentives, and education."*
>
> ***Renewable Energy Financing Case Studies: Lessons to be Learned from Successful Initiatives***. Martin Tampier and Jean-Philippe Beaulieu, Commission for Environmental Cooperation, Montreal. 2006. http://www.cec.org/files/pdf/ECONOMY/RE%20Financing%20Case%20Studies_en.pdf

Synopsis

The fundamental trend that is becoming evident with respect to the economic viability of renewable energy is not "if" but "when" and that when is now rapidly approaching. Most forecasts indicate that the 'least cost effective' renewable energy source, photovoltaic solar panels, is expected to be cost competitive with conventional electricity prices by the middle of the next decade, less than ten years from now. Solar thermal and wind energy are readily finding willing markets and displacing conventional energy sources. Biogas when combined with combined heat and power technology is a cost effective alternative to natural gas generated electricity when the costs of waste disposal are factored into the analysis. At the societal level, there are good reasons to aggressively pursue a renewable energy future. From the consumer perspective, renewable energy is a valuable investment and reliable buffer against rising energy prices. For developers, initial costs are expected to prove challenging in the short term, leveling off and approaching the same levels of cost effectiveness as most other energy conservation measures in building development. Regardless of the perspective, as a minimum, it is prudent to rough-in conduits that make the building "green ready" by easily enabling the future installation and connection of renewable energy systems. This approach can reconcile issues of affordability with the future migration to a cost effective and clean energy future.

Artificial Illumination

The use of artificial illumination began with the discovery of fire and has continually evolved ever since. Street lighting was a hallmark of cities and urban environments, first utilizing gas, then switching to electricity with the invention of the light bulb. Artificial illumination is now understood to mean electric lighting and it is used inside and outside of buildings. This section of the study examines the requirements of the Toronto Green Development Standard as they apply to reducing light pollution. This review focuses primarily on exterior illumination (street, parking lot and building lighting, including commercial sign lighting) since the control of interior building lighting was demonstrated to be a cost-effective earlier in this report.

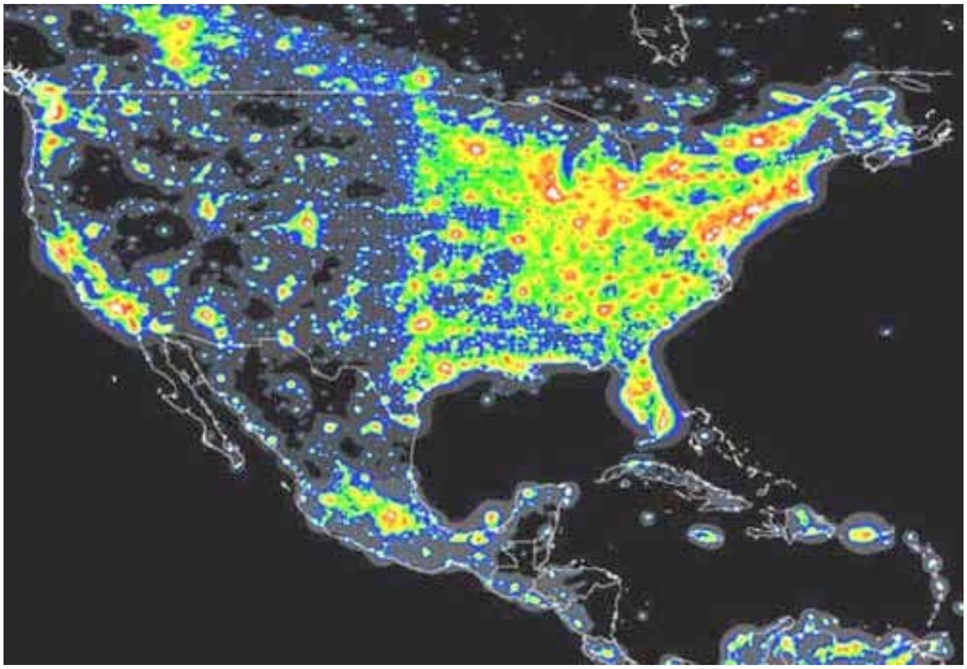

Figure 48. Artificial night sky brightness in North America as measured from outer space in 1996-97. [Credit: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder, Colorado)]

Artificial light is considered to contribute to a number of adverse effects that have been scientifically documented:[85]

- aesthetic effects (e.g., obscuring a nighttime view of the heavens);
- effects on the natural world (e.g., migratory birds, nocturnal animal behaviour);
- human health effects (increased sleep disorders and cancer rates);
- crime and accidents (increased rates due to ineffectual lighting); and
- energy use (wasted energy due to inefficient lighting and controls).

Toronto and the Greater Golden Horseshoe area is located at a latitude where on average, over the course of a year, there are practically as many daytime as nighttime hours. Artificial illumination therefore largely defines the quality of our urban environment for half of the time.

[85] *RCEP Consultation on Artificial Light in the Environment*. Martin Morgan-Taylor. Presented to the Royal Commission on Environmental Pollution's study of Artificial Light in the Environment. 2008. http://data.nextrionet.com/site/idsa/RCEP%20Cosultation%20on%20Artificial%20Light%20in%20the%20Environment.pdf

Light pollution is a term that is more familiar to astronomers and bird ecologists than the average person. As a society, we are becoming aware of the need to consider the effects of artificial illumination in urban environments.

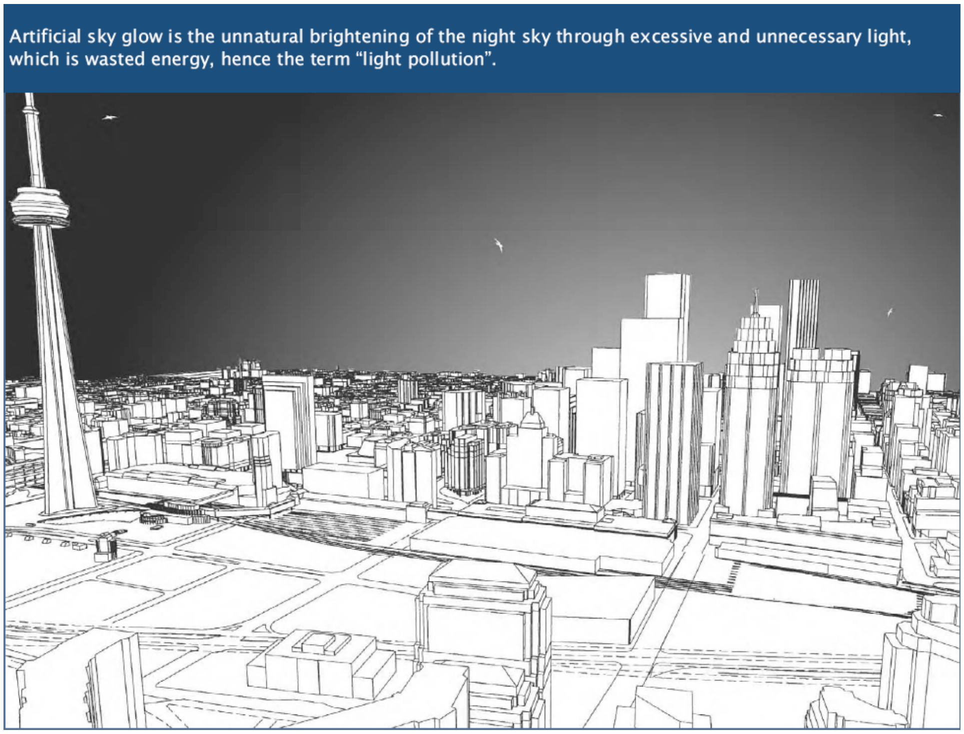

Figure 49. Definition of the term "light pollution" in Toronto's urban context. [Source: Bird Friendly Development Guidelines. City of Toronto Green Development Standard, March 2007. http://www.toronto.ca/lightsout/pdf/development_guidelines.pdf]

Nowhere are the effects of light pollution more poignantly revealed than in the annual bird fatalities which are largely preventable through the responsible design of artificial illumination systems and controls.

In the dark, and especially in foggy or rainy weather, the combination of glass and light becomes deadly. Confused by artificial lights, blinded by weather, and unable to see glass, birds by the hundreds and even thousands can be injured or killed in one night at one building. Over 140 different species of birds have collided with buildings in Toronto alone. One expert estimates that across North America, up to 100 million birds die in collisions each year. Many species that collide frequently are known to be in long-term decline and some are already designated officially as threatened. Compared to habitat loss, pollution, and over-hunting, the issue of building collisions is neither well-known nor adequately understood. Yet across North America, more birds die from collisions each year than succumbed to the Exxon Valdez oil spill.[86]

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[86] FLAP, Fatal Light Awareness Program. http://www.flap.org/

Figure 50. Over 2500 birds which flew into buildings because of lights left on were displayed at Metro Hall on May 3, 2007.
[Photo: René Johnston] http://www.thestar.com/News/article/210356

Lights in buildings can be cost effectively controlled to reduce bird fatalities and light pollution. To many "dark sky" advocates, parking lots and street lighting are the worst offenders, but now there are solutions that address the concerns of all stakeholders.

Figure 51. Most parking lots in new developments have inappropriate and over-powered lighting that is left on all evening, wasting energy and causing light pollution. [Photo: Celine Chamberlin]

The first solution comes from selecting appropriate exterior lighting fixtures and strategies. This is a critical design consideration that has received attention from organizations such as the Metro Toronto Action Committee on Public Violence Against Women and Children. Many conventional exterior lighting practices unintentionally pose greater safety risks to women and children in urban environments because they create high contrast levels that impair the visual detection and recognition of criminal elements. Examples of preferred lighting fixtures and strategies are depicted below. It should be noted there is no significant cost difference between these and less appropriate fixtures.

Figure 52. Downlighting that avoids placing the glare of the lamp in the pedestrian's field of vision is considered safer and more environmentally appropriate.
[Source: Bird Friendly Development Guidelines. City of Toronto Green Development Standard, March 2007. http://www.toronto.ca/lightsout/pdf/development_guidelines.pdf]

In addition to fixture and lamp selection, a number of innovative lighting control systems have been developed and brought to market in the past few years. These offer a huge potential to further reduce light pollution while saving energy.

The City of Prince George is testing light-sensing controls in 170 streetlights as part of the first remote street light management system in Canada. The project will allow Prince George to reduce its energy use and costs by approximately 40% by reducing over-lighting during off-peak hours when there is little vehicle and pedestrian traffic. The project is partially funded by a contribution from B.C. Hydro's Power Smart Program, which provides incentives to B.C. municipalities to promote new energy saving technologies. The complete DMD & Associates report is available at http://www.streetlightIQ.com.
[Source: Streetlight Intelligence Inc. http://www.streetlightiq.com/filez/pg_lsi_project.pdf]

Ville de Québec Smart Street Lights Save Energy with Echelon's Technology
(San Jose, CA - October 25, 2007) - Echelon Corporation, a leading provider of networking technology that is used to manage and reduce energy consumption, today announced that the Ville de Québec is using Echelon's technology to reduce energy use in the city's streetlight system. The remotely controlled and monitored streetlight system uses Echelon's LonWorks® power line technology and i.LON® Internet Server to reduce energy use at times of peak demand upon request from the utility. The system has been installed in approximately 200 streetlights in the historical district of the city as a trial project, with a planned installation of another 800 streetlights by early 2008. Long term, Ville de Québec plans to convert at least 1,000 lamps per year to the new system over the next ten years. Managed, smart street lights have been a largely European phenomenon driven by the high cost of energy pressuring limited civic budgets. The Ville de Québec pilot is the first LonWorks streetlight system in North America.

"Streetlights are a large consumer of energy for cities, using up to 40 percent of a city's energy budget. If every city installed a similar system, this would go a long way to reducing energy use worldwide and therefore reducing carbon dioxide levels," said Anders Axelsson, Echelon's senior vice president of sales and marketing. "We believe that energy management applications and control networks are often one and the same, delivering a great ROI based on energy and operational savings. With consistent savings of 30 to 50 percent on energy use, we believe it not only makes economic sense but it is also environmentally responsible for cities to invest in monitored streetlight systems."
[Source: http://www.echelon.com/company/press/quebec.htm]

There is a growing realization among various disciplines that in the early stages of urbanization and industrialization, from which we are now only beginning to emerge, our relationships with technology have not been symbiotic in any ecological sense. The application of artificial lighting in urban settings is a prime example of how, to quote Samuel Johnson, “the road to hell is paved with good intentions.” A recent multi-disciplinary study of modern social behaviour with respect to technology concluded that well-designed technical environments, systems, and products have a great potential for supporting environmentally sustainable behavior.[87] There is no reason we cannot achieve safely illuminated urban environments that do not cause environmental degradation.

While it was not possible to obtain documented measures of the cost effectiveness of installing more effective and efficient artificial lighting systems and controls, the observed migration by municipalities and private sector organizations towards these alternatives tends to support their feasibility in the marketplace. Technologies like smart grids for managing electrical energy, and web-based lighting management systems are now being implemented across North America. Concurrently, the energy efficiency and luminous efficacy of lamps and lighting fixtures is improving. There do not appear to be any barriers to the adoption of interior and exterior lighting strategies that address all of the adverse effects currently being experienced by our collective fascination with artificial lighting. It is reasonable to conclude at this point in time, and for the purposes of this study, that meeting the lighting requirements in the Toronto Green Development Standard is at worst, cost neutral to developers, but more likely highly cost effective due to the significant energy savings and greenhouse gas reductions associated with the management of artificial illumination serving building developments.

[87] *User Behaviour and Technology Development: Shaping Sustainable Relationships Between Consumers and Technology*. Peter-Paul Verbeek and Adriaan Slob, Editors. Springer Netherlands, 2006. ISBN 978-1-4020-4433-5

Urban Site Technologies Synopsis

Urban site technologies available to new development projects are numerous and varied. Unlike the energy conservation measures associated with the three model buildings examined earlier in this study, the cost effectiveness of urban site technologies cannot be so easily assessed in a typical context. But there is sufficient evidence in the published literature to be able to assemble a summary of costs and benefits.

Table 32. Summary of Urban Site Technology Costs and Benefits

Urban Site Technology	Costs	Benefits
Stormwater Management	▪ Additional initial costs limited to integrated design process, landscape architecture design fees ▪ Cost associated with changing codes, standards and regulations	▪ Less costly to construct than conventional technology ▪ Savings can fund other "green" site technologies ▪ Lowest life cycle operating and environmental costs
Water Management	▪ Negligible cost premiums associated with water efficient fixtures, appliances and equipment ▪ Largest cost component covered by stormwater management measures	▪ Avoided costs for municipality (purification and wastewater treatment) ▪ Lower water bills ▪ Lower energy bills for pumping within waterworks system and in high-rise buildings
Solid Waste Management	▪ Relatively cost neutral during construction when compared to "full cost" tipping fees and regulatory enforcement (fines) ▪ Marginal cost premium associated with providing suitable facilities in new developments to accommodate 3Rs and composting	▪ Conservation of materials ▪ Avoided cost of landfills ▪ Potential for electrical and heat energy generation from biogas obtained through source separated organics (composting) ▪ Potential for waste-to-energy systems for undiverted garbage
Renewable Energy	▪ Rough-in for future renewable energy ("green ready") is a marginal cost ▪ Depending on type, costs can range from marginal to significant up front investment	▪ Lower life cycle costs than any non-renewable energy source over 25-year period ▪ Non-polluting ▪ Secure ▪ Expandable
District Energy Systems	▪ Lower costs when compared to conventional HVAC system for each building served on a community basis	▪ Efficient ▪ Clean ▪ Decentralized ▪ Secure
Illumination	▪ Initial cost premiums associated with latest technology for reducing illumination and associated energy costs.	▪ Additional costs recovered in energy savings and reduced maintenance ▪ Reduced bird kills ▪ Habitat preservation

Some of the important issues that emerge from this review of urban site technologies and the previous cost-benefit analysis of energy conservation measures are presented below:

- The life cycle cost effectiveness measure is much more indicative of the true value of green development than payback period or rate of return. The assessment of energy conservation measures for three model building typologies indicted that for approximately 1 dollar invested, some 3 to 4 dollars in life cycle saving were realized over a 25 year period. There remains sufficient margin today to invest in an integrated package of energy conservation measures and urban site technologies while still yielding a reasonable rate of return. It is questionable whether double-digit rates of return are ethical, as they imply these returns come at the future expense of succeeding generations. If 3 to 4 dollars, rather than 1 dollar, could have been invested without economic hardship today, why is the present generation seeking to profit from an unsustainable future?
- Urban site technologies like landscape infrastructure are cost effective today and deliver superior environmental performance. They increase land values and free up development capital to invest in less cost effective technologies.
- Renewable energy is an example of a less cost effective green technology. It is cost effective over a 25-year period and beyond, but under the present development framework there are initial cost barriers. Life cycle savings from energy conservation measures and landscape infrastructure alternatives can easily finance renewable energy and district energy systems in new developments. Integrated design, responsive regulations and creative financing instruments must be orchestrated to realize these immense potential benefits.
- Water conservation remains the real challenge of green development. Logically, as the population being served by the City of Toronto's aging infrastructure grows, both the per capita water consumption must come down and the cost of water rise. Otherwise, the renewal of this vital urban site technology is in severe jeopardy. Water is the ultimate and most reliable barometer of sustainability in urban settings – present indications are not encouraging and deserve serious consideration.
- Water conservation and solid waste management are examples of programs that necessarily rely on social and cultural contributions, in terms of behaviour and attitude. Consumer expectations of avoiding the life cycle costs associated with their consumption patterns are unrealistic. Technology is only as effective as the intentions of its users. Public education should be viewed as a constant cost component of a sustainable future.
- Contrary to many deeply held convictions of the business community, there are absolute limits to growth in the Greater Toronto Area and the Greater Golden Horseshoe, assuming a minimum acceptable quality of life, economy and the environment. The ultimate threshold of sustainability can only be determined empirically, by collapsing the social, economic and environmental systems that support our way of life. There is a need to develop realistic plans and visions of our common future.

Further to the assessments and reviews performed up to this point in the study, another important task remains – the exploration of the opportunities associated with green development. Are there additional benefits associated with green development and the new economy it engenders? The next part of this study attempts to answer this important question.

Green Development Innovation Opportunities

"The opportunities in environmental careers are exploding. Demand is outstripping supply and it's affecting industry's ability to meet the environmental challenge. Right now, there are 530,000 jobs in Canada related to the environment, and we are projecting job growth over the next five years to increase by 8.8 per cent. This represents a rate that is 24-per-cent faster than the overall Canadian employment increase."

Grant Trump, president of the Calgary-based Environmental Careers Organization of Canada, quoted in ***Green Jobs Take Root and Proliferate*** by Diana McLaren, Globe and Mail, Toronto, February 14, 2008.

Green development is a necessary part of tomorrow's green economy. But is a green economy a necessary part of tomorrow? Canadians have always referred to themselves as hewers of wood and drawers of water, part of a resource based economy. Historically, Ontario has always been split into urban, rural and hinterland economies with most of its wealth coming from manufacturing jobs in the Greater Golden Horseshoe (GGH) region. According to Statistics Canada, many of these traditional economic relationships are changing.

"*A number of structural and cyclical factors have reduced the importance of forestry products in Canada's exports. Instead, since 2002 there has been a large shift in the resource sector away from trees and towards commodities found mostly underground, notably oil and metals. Rather than being 'hewers of wood and drawers of water', it is more accurate (if less catchy) to say Canadians are 'conveyers of crude and moilers of metals'*."[88]

In Ontario, the manufacturing sector is giving way to a knowledge-based economy. A 2003 Neptis Foundation report on smart growth in southern Ontario provides useful insights into the future trends and opportunities.

- *Traded clusters consist of industries that sell their output to non-local markets. Local clusters provide goods and services to the area in which they are located.*
- *The Institute for Competitiveness and Prosperity has found that traded clusters provide 41% of Ontario's total employment.*
- *Most local demand for goods and services produced by local industries originates with the income generated by a region's traded industries.*
- *Economists generally agree that the defining feature of capitalism today is the importance of knowledge in the creation of economic value and the determination of competitive success.*
- *Much innovation occurs through the interaction of economic actors: for example, between technology customers and technology producers, or between partnering technology producers*.[89]

The future of green development will hinge on the availability of knowledge workers who can integrate environmentally appropriate technologies. Innovation will come about if those knowledge workers (architects, engineers, etc.) can interact with green technology producers. This implies the green technology products will be manufactured locally and the knowledge workers can work out bugs and suggest refinements on a project-by-project basis across the GGH. The RDDI cycle of research, development, demonstration and implementation is the key to building construction and infrastructure innovation, and ultimately trade exports. Ontario, by means of the Toronto Green Development Standard, can simultaneously drive green development technologies and knowledge-based services. Alternatively, innovative firms like Arise Technologies will be lured to countries like Germany where financing of solar energy manufacturing plants makes for an inviting business climate.[90] A crisis similar to that looming in Ontario's auto industry can be averted by the green development industry if it strikes a path toward a sustainable future.

[88] Statistics Canada, 2007. "The new underground economy of subsoil resources: no longer hewers of wood and drawers of water". *Canadian Economic Observer*, October 2007, feature article. Statistics Canada catalogue no. 11-010-XWB. http://www.statcan.ca/english/freepub/11-010-XIB/11-010-XIB2007010.pdf
[89] *Smart Growth and the Regional Economy*. Meric Gertler, Neptis Foundation, 2003. http://www.neptis.org/library/show.cfm?id=74&cat_id=7
[90] *Lessons from Germany's Energy Renaissance*. Eric Reguly, Globe and Mail, March 22, 2008.

To a large extent this path already exists, but it needs to be widened, lengthened and smoothed out, otherwise the green economy will take the path of least resistance elsewhere in Canada or the world. This reality has guided the formation of entrepreneurial organizations that have evolved from a smokestack industry environment to take advantage of the clean technology revolution.

Cleantech Defined

Clean is more than green. Clean technology, or "cleantech", should not be confused with the terms environmental technology or "green tech" popularized in the 1970's and 80's. Cleantech is new technology and related business models offering competitive returns for investors and customers while providing solutions to global challenges. Where greentech, or envirotech, represents the highly regulatory driven, "end-of–pipe" technology of the past with limited opportunity for attractive returns, cleantech is driven by market economics, therefore offering greater financial upside and sustainability. The concept of cleantech embraces a diverse range of products, services, and processes across industry verticals that are inherently designed to:

- *Provide superior performance at lower costs;*
- *Greatly reduce or eliminate negative ecological impact; and*
- *Improve the productive and responsible use of natural resources.*

Cleantech spans many industry verticals and is defined by the following eleven segments:

- *Energy Generation*
- *Energy Storage*
- *Energy Infrastructure*
- *Energy Efficiency*
- *Transportation*
- *Water & Wastewater*
- *Air & Environment*
- *Materials*
- *Manufacturing/Industrial*
- *Agriculture*
- *Recycling & Waste*

Establishing What is a Cleantech Company and Deal

Determining what is cleantech isn't always easy. CN researchers established and continue to refine criteria which are applied to the technology to ensure consistent reporting of the data for the North American, European, Israeli, and Chinese markets. These criteria have been applied to all North American venture deals done from 1999 and European and Israeli deals since 2003 and North American, European, Israeli, and Chinese M&A, and IPO for the past two years. The same criteria are applied to companies that are screened and selected to present at our Cleantech Forums® globally.

[Source: Cleantech Network, http://cleantechnetwork.com/index.cfm?pageSRC=CleantechDefined]

Ann Arbor, Mich.-based Cleantech Network said today that venture capitalists handed out $1.74 billion in the third quarter in North America and Europe. The research group said that's a 13 percent increase over the same period in 2006.

"The combination of a rapidly improving pipeline of venture grade deals, favorable public policy trends and growing consumer awareness of climate change continue to point to a positive outlook for the future growth of clean technologies," said Nicholas Parker, chairman and co-founder of the Cleantech Group, parent company of the Cleantech Network.

North American VC investments hit a new high of $1.26 billion, representing a 50 percent increase over the previous quarter and a 36 percent increase over Q3 2006.

Cleantech Network. Oct. 26/07 http://media.cleantech.com/1980/vcs-pour-1-7b-into-cleantech-in-q3

Opportunities for innovation arising from green development imply investment and job creation founded on sustainable economic activities. Clean, green technologies are not only suitable to new development, but also the rehabilitation of existing developments all across the Great Lakes region. The sections that follow examine these opportunities and then assess their associated issues and potential economic benefits.

Technology Innovation Opportunities

In the course of performing this study, an informal survey of the research, design and development, and construction communities was conducted. The listing of technology innovation opportunities that follows is not exhaustive, but identifies areas where Ontario could command a leading edge in global markets. This following list identifies areas above and beyond the numerous urban site technologies presented in the preceding section of this report, primarily renewable energy and landscape infrastructure.

Intelligent / Adaptive Facades

The commonly accepted term 'intelligent façade' is somewhat deceiving because, strictly speaking, these systems are unable to comprehend, reason and learn, hence they are more correctly referred to as adaptive façades. These automated systems incorporate a variety of devices whose control adaptability enables the building envelope to act as a climate moderator. Through the use of predictive control algorithms within a building automation system, the façade is able to accept or reject free energy from the external environment, reducing the amount of purchased energy. The sophistication of these systems is evidenced in their integration of optimal building energy performance with individual occupant control of thermal and visual comfort.

During the phase of this study where energy simulations were carried out to assess energy performance, it became evident that being able to modify the thermal and optical properties of the different façade orientations (north, south, east, west) provided energy conservation benefits. However, the cost of providing these control capabilities was very high and the devices, such as shading fins, were typically fixed or static, unable to respond to changing conditions on a daily or seasonal basis.

The European approach to adaptive façades has been piloted on several building projects in Canada (e.g., Manitoba Hydro Building, Centre for Cellular and Biomolecular Research, University of Toronto), but there remains a potential to develop technologies suited to Canadian climate conditions. A large proportion of façade systems used in Ontario are based on foreign design and manufacturing. Often these do not account for cold climate conditions and weather phenomena. The trend towards energy efficient new buildings and the retrofit of existing buildings presents an opportunity to develop a ‘made in Ontario’ solution to both conventional and adaptive facades.

Photovoltaic and Thermal (PVT) Solar Panels

PVT technology is rapidly evolving as it attempts to develop panels that convert solar energy into both electricity and heat for use in buildings. A major technical problem is that photovoltaic panels become less efficient in converting solar energy into electricity as their temperature increases. Solar thermal panels, for heating air or water, deliver their best performance at elevated temperatures. Several research programs in response to this challenge are underway at Ontario universities, and the initial results hold promise for a technology that can be integrated into the building envelopes of buildings and serve three purposes: cladding; electrical generation; and thermal capture.

PVT systems represent a critical advance in building technology because in many cases, the cost of buying separate photovoltaic and solar thermal systems is prohibitive. Where the economics are favourable, there may be insufficient solar access for both systems (i.e., insufficient unobstructed south-facing surface area). PVT technology can address issues of building envelope integration, performance and cost effectiveness.

Trigeneration

Combined cooling, heating and power (CCHP) systems, also referred to as building cooling, heating and power (BCHP) systems, are based on the idea of trigeneration: the concurrent production of cooling, heating and electricity. It is a relatively new technology compared to co-generation. Presently, the process of integrating these capabilities into a reliable on-site power system is technically challenging. The current state of the art is similar to what occurred at the beginning of the personal computer revolution where small vendors assembled custom systems from components. Going to a 'big box' retail outlet, selecting from a large number of choices, and taking the system home for immediate use marks a huge advance in the diffusion of computer technology. A comparable evolution is beginning with trigeneration. When combined with the potential for bio-fuels and district energy systems, trigeneration systems will become a cost effective alternative in many new building developments, especially hospitals, laundries, food-processing plants, hotels, educational facilities, office buildings, data centers, nursing homes, supermarkets, refrigerated warehouses, retail stores, and restaurants. There are no wholly Ontario-based manufacturers of trigeneration technology and most of the system components are designed and manufactured outside of Canada.

Integrated Fan Coil / Heat Pump / Energy Recovery Ventilation (ERV) Technology

The predominant technology for heating and cooling condominium suites is the two-pipe fan coil unit. A typical unit consists of a cabinet housing a heat transfer coil and a fan. Two pipes are connected to the coil supplying either hot or chilled water on a seasonal basis. The fan blows air through a system of ductwork in the suite to condition the air. An electric heating coil is normally provided to heat the air in case of cold periods occurring after the 2-pipe system has been switched over to cooling mode. There is no ventilation provided by conventional units. Ventilation air is provided by a separate system that delivers outside air to the hallways on each floor. This air is intended to migrate into each suite via the gap at the bottom of the entry door for each suite. Kitchen and bathroom fans in each suite exhaust stale air to the outside. According to numerous reports by CMHC, this Code-minimum system has questionable ventilation effectiveness and is not energy efficient because it does not incorporate heat recovery. Mold problems in the condensate pan of these units have also been widely reported.

There is currently a single Ontario manufacturer of an alternative technology that combines fan coil technology with heat recovery (energy recovery addresses both heat and moisture capture). Heat pump technology is not integrated with the existing technology. Research and development of such integrated environmental control systems is needed to address issues of energy efficiency and indoor air quality. As one industry representative who wishes to remain anonymous stated, "You get a better HVAC system when you buy a car that costs a tenth of the price of a new condo."

Smart Energy Grids

The idea of managing energy like digital information is a recent development in the energy field. Touted largely for improving energy efficiency, smart energy grids are also supposed to enhance reliability and avoid events like the widespread blackout that occurred across much of Ontario and the northeastern United States on August 14, 2003.

When Times Square flickered out below him, the pilot feared he was witnessing a terrorist attack. Beneath the suddenly dark canyons of Manhattan, subway trains lurched to a stop, stranding hundreds of thousands of rush-hour commuters. To a satellite in orbit, it must have looked like a major constellation was being snuffed out. First Toronto went black, then Rochester, Boston, and finally New York City. In just 13 minutes, one of the crowning achievements of industrial engineering - the computer-controlled power grid of the 80,000-square-mile Canada-United States Eastern Interconnection area - was toast. For the first time in decades, night held dominion over the cities of the Northeast, which were now without traffic signals, television, airport landing lights, elevators, and refrigeration.

The best minds in electricity R&D have a plan: Every node in the power network of the future will be awake, responsive, adaptive, price-smart, eco-sensitive, real-time, flexible, humming - and interconnected with everything else

The Energy Web. Steve Silberman, Wired Magazine, September 2007.
http://www.wired.com/wired/archive/9.07/juice.html

Smart energy grids are part of an energy networking concept that is emerging across North America, and they are intended to interact with building automation systems and smart appliances and equipment. One of the key ideas is to have buildings control themselves while being voluntarily controlled so that on days when a system peak is predicted, connected buildings adjust their energy consumption and shed loads to avoid the peak. This is one among a number of capabilities that will enable renewable energy producers to automatically market their production at the highest rates.

Ontario is poised to implement the 'energy web' and there are a number of potential innovations that can be researched, developed and implemented. Ontario must choose if it wants to become an innovator and supplier of smart energy grid technology, or simply an adopter.

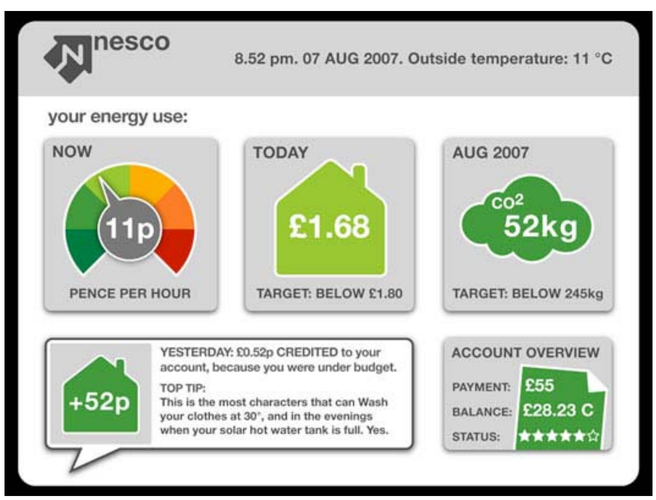

Figure 52. Low Carb Lane TV-based home energy dashboard. Example of smart metering used to give customers feedback on energy consumption. This technology helps conserve energy and reduce peak electricity demand.
[Source: http://www.dott07.com/go/lowcarblane]

Demand-Controlled Ventilation (DCV)

During this study's assessment of the cost effectiveness of energy conservation measures, demand-controlled ventilation was identified as one of the best investments for buildings where high occupancy and intermittent use were combined (e.g., retail, offices, auditoriums/theatres, etc.). According to the U.S. Department of Energy:

Demand-controlled ventilation (DCV) using carbon dioxide (CO_2) sensing is a combination of two technologies: CO_2 sensors that monitor CO_2 levels in the air inside a building, and an air-handling system that uses data from the sensors to regulate the amount of ventilation air admitted.

CO_2 sensors have been available for about 12 years. An estimated 60,000 CO_2 sensors are sold annually for ventilation control in buildings, and the market is growing. There is a potential for millions of sensors to be used, since any building that has fresh air ventilation requirements might potentially benefit from the technology.

Costs for sensors have dropped by about 50% over the last several years. Sensors typically cost about $250 to $260 each, uninstalled. For a new system, the installed cost will generally be about $600 to $700 per zone.

[Source: *Demand-Controlled Ventilation Using CO_2 Sensors*. U.S. Department of Energy, Energy Efficiency and Renewable Energy, March 2004.]

Research in Ontario on advanced applications of laser technology to the instantaneous analysis of air/gas composition holds the promise of developing a new era of carbon dioxide sensors for DCV systems that will decrease costs ten-fold while improving on accuracy and reliability. The new technology has the advantage of being able to simultaneously monitor more than one gas concentration, suggesting it is useful in many industrial ventilation applications.

Integrated Urban Development Simulation Tools

Throughout the course of this study, a number of different tools were used to assess various aspects of green development. Research work by others referenced in the study indicated yet another layer of tools and techniques used to assess performance indictors like emissions, air quality and biodiversity, to name a few among a host of indicators that are needed to determine sustainability, particularly within an urban context. Interestingly, the concept for this type of a planning, design and analysis tool originates in a video game called *SimCity* introduced in 1989. It has since evolved:

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*Featuring an all-new, revolutionary feature set, **SimCity Societies** allows you to create your own kinds of cities and shape their cultures and environments. Make your cities green or polluted, contemporary or futuristic, rural or urban. Create an artistic society or a police state, an industrial city or a spiritual community - or any society you want!*
Source: *SimCity Societies*. http://simcitysocieties.ea.com/about.php?languageCode=1]

Questions, like those that this study attempted to answer, and that deal with the planning, design and management of urban settlements, necessarily involve complex relationships. Separate models for each of these relationships exist in some form or other, but none of these have been integrated into a robust tool capable of informing critical decisions about the future of our cities. If there is a single technology that is sorely needed by all levels of government, the private sector and academic institutions, it is a software that fosters multi-disciplinary research into the appropriate policies and practices that can advance sustainable development.

Service Innovation Opportunities

Green development is not only about green technologies. The level of service needed to plan, design, construct and operate green communities is at least as high as in the conventional development field. While many of the services are simply a re-tooling of existing services (for example, training plumbers to install solar water heating systems), there are many services that are either just emerging or non-existent. This section looks at the most critical services needed to deliver green development. It is important to keep in mind that these services are presently responding to a relatively marginal market demand. To appreciate their significance, it is necessary to imagine a wholesale migration to green development. In the GTA, the most recent scenario that reflects this future possibility is the residential renovation boom. People are waiting years in some cases to have renovation work performed that is inflated in price, and often substandard. Green development is no better prepared for its human resource challenges.

Energy Simulation and Cost-Benefit Analysis

During the course of this study, developers, utilities, designers and consultants all expressed the view that there were insufficient numbers of qualified personnel with the ability to perform energy simulations and cost-benefit analyses for buildings. There is no formal program of study, either at the community college, undergraduate or graduate levels in Ontario that provides suitable educational opportunities. Normally, individuals with an engineering background are trained on the job by senior staff. In addition to this shortage of skilled personnel there is no standard in place, similar to what exists for structural or electrical engineering, that governs proper principles in professional practice. As a result, energy simulations and cost-benefit analyses remain largely a ‘buyer beware’ service in Ontario. Under the present conditions, reputable consulting firms have been able to responsibly respond to the relatively low demand for this nature of work, but it is generally acknowledged this is definitely a bottleneck in the green development process.

Energy and Performance Labeling

Strongly related to energy simulation is the more general field of energy and performance labeling of buildings. Jurisdictions, such as the European Union, have for some time now issued directives making energy and environmental performance labeling of all buildings mandatory – new and existing. This practice has been identified as an essential component of public education needed to transform the market. In Ontario, a consumer can purchase a light bulb for several dollars and its energy performance is clearly labeled on the lamp, certified by a third party (i.e., CSA, 25 Watts). Similar information about the performance of a building costing a hundred thousand times more is not required at this time in Ontario, but without a reliable measure of the energy and water efficiency of buildings, along with the size of their ecological footprint, it is difficult to fairly market the benefits of green buildings and developments.

Ontario has an opportunity to take a leadership role in the energy and performance labeling of buildings. Performance assessment software coupled to proper standards and guidelines require development. Suitably qualified and trained personnel are also needed to carry out the millions of assessments to capture the existing building stock, and the hundreds of thousands of annual new buildings and retrofits. Similar to the scale and scope of property value assessments, energy and performance labeling is a necessary service supporting Ontario’s green development future.

Green Design, Construction and Facilities Management

The availability of green design services is not widespread across Ontario. Most of the expertise is clustered among a small proportion of practices, with a majority of the design services responding to conventional development demands. The curriculum at professional schools of design is only now beginning to reflect green design interests, but not in a substantive way. Accreditation requirements for most professions focus on fundamentals and traditional subject matter. This tends to cause a dilemma because design practices wishing to pursue green development opportunities may not be able to hire suitably qualified personnel, and developers interested in green development worry they may be confined to a handful of practices that are inundated with work and therefore tend to have higher fee structures. Expanded demand for green development would cause practices to hire and/or train additional personnel, but the reluctance on the part of the development community is justified.

Urban planning, architecture, landscape architecture, engineering and interior design are the chiefly affected disciplines most in need of proper educational programs that support the green development agenda. As an example, mechanical engineering schools in Ontario no longer offer more than a single course in heating, ventilating and air-conditioning (HVAC) principles. There are no applied courses, hence it is unlikely students will be introduced to any form of energy modeling and renewable energy systems design. The same can be said for civil engineering where low impact development techniques for stormwater management do not form part of the compulsory curriculum, whereas the design of systems to rapidly convey pollutants into waterways is strictly observed. Daylighting, natural ventilation, water conservation, public transportation and a host of other subjects that underpin green development are woefully absent from design curricula.

Green development is based on the concept of integrated design for the whole life cycle. This design process is followed by construction, commissioning, operation and management of the development. Education and training in these allied professions is also lacking across Ontario, such that even if there were sufficient green design capacity and competence, they would not be able to fulfill the green design mandate.

Ontario has enjoyed a vibrant development industry for over a decade. As noted earlier in this report, the R&D budget of one of the strongest sectors of the economy is virtually non-existent. Industry is in an ideal position to partner with government and academia to bring design, construction and facilities management education into the 21st century.

Green Trades

There is an acknowledged shortage of green trades in Ontario, especially in the renewable energy sector where there are insufficient technicians and installers available to meet current demand in a timely manner. Landscape infrastructure trades that can competently construct landscapes for stormwater management as efficiently as they now place piping, catchbasins, curbs and gutters, are also lacking. Government has the ability to work with industry to re-structure and re-orient trades training and education in Ontario. The green trades hold a special appeal to a younger generation that places a high value on environmental stewardship. In looking at the issues facing the design, construction and facilities management profession, the opportunity for green trades development is a logical extension of a comprehensive strategy to furnish Ontario with the human resources needed to achieve the highest levels of green development possible.

> *A central issue was identified by industry representatives who described the growth in energy efficiency training as "fragmented" and "ad hoc." Although some individual instructors have incorporated content on energy efficiency into their courses, construction trades apprenticeship programs teach to the Building Code and have not integrated energy efficiency as a significant focus to date. Industry representatives also describe current apprenticeship programs as rote learning designed to produce a set of narrow trade-based "competencies" rather than an understanding of the work of the trade in the context of the whole building.*
>
> ***Skills for Energy Efficient Construction**: A Report on Trades Training for Energy Efficient Buildings in the Greater Toronto Area.* Clean Air Partnership, March 2007.

Innovation Issues

The lean, clean, green economy of the 21st century is certainly based on the recruitment and retention of knowledge workers. Researchers such as Richard Florida of the Martin Prosperity Institute at the University of Toronto have offered prescriptions for attracting this 'creative class' of knowledge workers. Green development is one of the attractors, but not in and of itself. It is an indicator of a social and cultural attitude toward sustainability that is manifest in environmentally sensitive development interventions. Underpinning this creative crust is a complex network of technically skilled and proficient workers that can execute designs which convert ideas into reality, be these films, museum exhibits or live/work communities.

In the green development industry, designers and constructors are the key knowledge workers needed to execute building projects. Architects, engineers, landscape architects and project managers work alongside quantity surveyors, building scientists and specification writers to define not just what is to be built, and how it is to be built, but more importantly, how it will perform in relation to codes, standards and societal expectations. Without this 'creative class' of the construction industry, green development remains an unrealized ambition.

The supporting actors in this epic of sustainable development are the skilled workers who layout, construct and commission the buildings and supporting infrastructure. These are rapidly becoming an endangered species in a world where much higher status and prestige are attached to knowledge workers. Nearly 50,000 workers in the Ontario construction industry are set to retire in the next several years and there does not appear to be a replacement strategy in place at the provincial level. According to Globe and Mail reporter Murray Campbell, "*At the very least, the looming skills shortage threatens to lead to slower economic growth and curtail the ability of governments to finance the cost of providing health care to the cohort of people over 65 years, whose numbers will nearly double by 2030*." Stephen Bauld of the Ontario General Contractors Association stated, "*You can only build so much if you don't have the people*." [91]

Bridging across both cohorts is the issue of education and training. For the knowledge workers, achieving the leading edge of professional practice assumes post-secondary institutions that offer relevant programs of study, and can attract and retain academic leaders who excel at teaching and research. Maintaining the edge demands professional development programs that respond to changing needs and integrate the latest knowledge into accessible programs. For skilled workers, the issues are similar but more hands-on. Integrating renewable energy technologies and intelligent facades with building automation systems is not something to be accomplished by trial and error in the field. Even traditional trades like forming and placing concrete for building structures will demand improved dimensional tolerances to accommodate advanced building skins. As the approximate becomes replaced by the exact, the construction trades will evolve from purely manual labour to a hybrid skill set involving sophisticated machines and computers. The educational infrastructure needed to develop and sustain the green development knowledge base is a recognized challenge. It is a critical component in the complex social machinery that needs to be designed, operated and maintained so that it can effectively realize any vision of a sustainable future.

[91] *Skilled workers a retiring species*. Murray Campbell, Globe and Mail, Tuesday, March 4, 2008.

Economic Costs and Benefits

What happens if the City of Toronto aggressively pursues the green development agenda? Given the relationship between the economies of the GTA and Ontario, this will result in a massive provincial shift away from non-renewable energy and inefficient development technologies. The costs of engaging this transition are unknown in terms of the opportunities presented in this section of the study, but a large component of current costs is associated with training and education geared to obsolete and dysfunctional technologies. The remaining costs represent investments by a variety of stakeholders that would yield long term economic benefits. A number of studies have attempted to estimate the benefits of the renewable energy and energy efficiency industries. These are briefly summarized blow.

Potential solar job creation in Ontario by 2025

Technology	Jobs	Per unit	Market Size in 2025	Units		Jobs in 2025
PV	35	1 MW	Annual sales	135	MW	4,725
			Total installed	1,232	MW	Not available
Solar air ventilation	5	1,000 m²	Annual sales	825,000	m²	4,125
			Total installed	3,600,000	m²	Not available
Solar pool	12	1,000 systems	Annual sales	7,000	Systems	84
	1.6	1,000 systems	Total installed	121,000	Systems	194
Solar hot water	6	1,000 m²	Annual sales	1,719,000	m²	10,314
Total						**19,442**

Table 33. Solar industries job creation potential in Ontario by 2025.
[Source: *Job Creation Potential of Solar Energy in Canada*. CanSIA Issues Report V3.0, Canadian Solar Industries Association, January 2005.]

CanSIA has estimated that the solar energy industry could create nearly 20,000 jobs in Ontario by 2025. The estimate is broken down in Table 33. The David Suzuki Foundation estimates that," *Using the same assumptions as a recent economic impact study of Quebec's 1,000 MW tender for windgenerating capacity, 8,000 MW of wind capacity installed in Ontario could produce nearly $14 billion in economic activity and 97,000 person-years of employment*."[92]

Studies in the United States tend to reinforce the trends identified in Canadian studies:

"*Transitioning from a fossil fuel–based economy to a renewably powered one will spur economic growth and provide considerable employment. A review of 13 studies and our own analysis concur with this conclusion. The national and international security implications of spurring employment through local, sustainable energy generation are compelling. The United States needs to regain its international position as a technology leader, and the technologies of the future are in clean energy. The time is ripe to move beyond studies to action*."[93]

[92] *Smart Generation: Powering Ontario With Renewable Energy*. The David Suzuki Foundation, 2004.
http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf
[93] *Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?*
Daniel M. Kammen, Kamal Kapadia, Matthias Fripp. Report of the Renewable and Appropriate Energy Laboratory, University of California, Berkeley, April 13, 2004 (Corrected January 31, 2006).
http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf

The most recent U.S. study forecasts the revenues and job creation potential associated with renewable energy and energy efficiency (RE&EE) industries by 2030 in Table 34.

	Revenues (Billions of 2006 Dollars)			**Total Jobs Created** (Direct Plus Indirect – Thousands)		
	Base Case	Moderate Scenario	Advanced Scenario	Base Case	Moderate Scenario	Advanced Scenario
RE	$95	$227	$597	1,305	3,138	7,918
EE	$1,818	$2,152	$3,933	14,953	17,825	32,185
Total	$1,913	$2,379	$4,530	16,258	20,963	40,103

Source: Management Information Services, Inc. and American Solar Energy Society, 2007.

Table 34. Projected revenues and jobs created by the U.S. renewable energy and energy efficiency industries in 2030.

A Clean and Prosperous Future for Ontario?
How does the renewable energy and energy efficiency (RE&EE) industry promise translate to Ontario?
By 2030, Ontario's share of the RE&EE industry could amount to approximately $95 billion annual revenues and provide 838,000 jobs.
The vast majority of these jobs and revenues would be generated in the Greater Golden Horseshoe Region.

Insights offered by this American Solar Energy Society funded study are summarized below:

"Renewable energy and energy efficiency technologies (RE&EE) are driving significant economic growth in the United States. In 2006, these industries generated 8.5 million new jobs, nearly $970 billion in revenue, more than $100 billion in industry profits, and more than $150 billion in increased federal, state, and local government tax revenues. Additionally, RE&EE provided important stimulus to the beleaguered U.S. manufacturing industry, displaced imported oil, and helped reduce the U.S. trade deficit. To put this in perspective, RE&EE sales outpaced the combined sales of the three largest U.S. corporations. Total sales for Wal-Mart, Exxon- Mobil, and General Motors in 2006 were $905 billion.

If U.S. policymakers aggressively commit to programs that support the sustained orderly development of RE&EE, the news gets even better. According to research conducted by the American Solar Energy Society (ASES) and Management Information Services, Inc. (MISI), the renewable energy and energy efficiency industry could—in a crash effort—generate up to $4.5 trillion in revenue in the United States and create 40 million new jobs by the year 2030. These 40 million jobs would represent nearly one out of every four jobs in 2030, and many would be jobs that could not easily be outsourced."[94]

How does the renewable energy and energy efficiency (RE&EE) industry promise translate to Ontario? World Bank statistics for 2006 indicate that the gross domestic product for the United States was $13,201,819 million versus $1,251,463 million for Canada, roughly a factor of 10. Ontario accounts on average for 39.9% of Canada's GDP[95], and 38.8% of Canada's population[96]. Assuming the moderate scenario from Table 34, by 2030 Ontario's share of the RE&EE industry could amount to approximately $95 billion annual revenues and provide 838,000 jobs. The more advanced scenario predicts about $180 billion in annual revenues and 1.6 million jobs. The vast majority of these jobs and revenues would be generated in the Greater Golden Horseshoe Region.

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[94] *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*. Roger Bezdek, Management Information Services, Inc. for the American Solar Energy Society (ASES) 2007. http://www.ases.org/ASES-JobsReport-Final.pdf
[95] Statistics Canada. Gross domestic product, expenditure-based, by province and territory, 2002-2006. http://www40.statcan.ca/l01/cst01/econ15.htm
[96] Statistics Canada. Population by year, by province and territory, 2003-2007 http://www40.statcan.ca/l01/cst01/demo02a.htm

There would also be losers in the transition to green development for a green economy. Fossil fuels related industries would experience recession and huge job losses. According to the University of California study, workers who lose their jobs in the fossil fuel industry should have the opportunity to retrain themselves for employment in the clean energy industry. Programs could include: free or low-cost training and certification courses in installation and maintenance of renewable energy systems; financial/tax incentives for renewable energy companies which absorb and train unemployed workers; and support for community colleges and schools that offer training and certification programs in renewables and energy efficiency. But on the whole, studies indicate there would be more winners than losers, in particular, the environment and the succeeding generations who inherit it.

A recent study on skilled construction trades in the Greater Toronto Area provides noteworthy conclusions and recommendations that are applicable to many facets of the green development industry:[97]

- *Ontario's building and construction sector is beginning to adopt energy efficiency practices that could transform the marketplace. The pace of this transformation will depend on market demand, new standards and regulations, and the transfer of skills and knowledge about energy efficient building systems and products to trades, technicians and professionals.*
- *A key finding of our research is that energy efficient construction requires a better understanding among tradespeople about how the building works as a system, and how the work of each trade intersects with that of other trades to contribute to well-functioning, high performance buildings.*
- *We found that the major barrier to expanded energy efficiency training for the trades is that the demand for energy efficient buildings is not yet sufficient to trigger the requisite changes in the training system. Many industry representatives who participated in this research argued that stronger regulatory requirements are needed to drive demand for energy efficient buildings and transform the marketplace.*
- *The conservatism of the industry and its focus on lowest capital costs (rather than operating costs) was also singled out as a major barrier to energy efficient construction and training.*
- *The low-rise residential sector has been the slowest to develop energy efficient practices. The fragmentation of the sector makes it difficult to reach builders. Many tradespeople are not unionized and have no connection to the training system. Homebuyers also need to better appreciate the advantages of energy efficient construction and make it a priority in their housing choices.*
- *In the short- to medium-term, a clearinghouse website should be established to provide coordinated information for tradespeople and building operators on available training opportunities.*
- *A working group of government, building industry and training organizations should be established to investigate and recommend ways to more effectively integrate energy efficiency into current training of construction trades and building operators.*
- *The Province should ensure more systematic training of building operators in efficient energy management by reinvesting in Energy Training Ontario.*
- *A more systematic program is needed to retrofit low-income and social housing for energy efficiency, and to engage and train social housing residents, unemployed youth and other disadvantaged groups in the work.*

All development, green, sustainable or otherwise, hinges on technology and the human resources needed to implement that technology. The transformation of Ontario into a jurisdiction promoting green development and advocating sustainable growth is imminent, largely for reasons of economic competitiveness. Pursuit of the opportunities identified in this section of the study can provide significant economic advantages to Ontario and establish it as a green development leader.

[97] *Skills for Energy Efficient Construction. A Report on Trades Training for Energy Efficient Buildings in the Greater Toronto Area*. Clean Air Partnership, March 2007. http://ttb.on.ca/downloads/SEEC.pdf

Green Development Cost-Benefit Matrix

> *"Now, the important next step for sustainability initiatives at the local level is to determine whether or not these actions are leading a community to become more sustainable. A significant barrier to accomplishing this task is the absence of a clearly articulated methodology for reporting on urban sustainability. Urban sustainability reports include a range of information about environmental, economic, and social conditions and policies in the local community and use that information to make judgements about whether the community is making progress towards sustainability. Evidence of positive progress is important for justifying past expenditures on sustainability initiatives and building support for new initiatives. Evidence of a lack of sustainability can provide ammunition for community groups to demand more action from local government, other levels of government, or the private sector. Individuals in the community also can use sustainability reports to educate themselves about sustainability trends and evaluate how their own actions may improve sustainability."*
>
> Virginia W. McLaren. ***Urban Sustainability Reporting.*** Journal of the American Planning Society. Vol.62, 1996.

The primary purpose of this study was to perform a cost-benefit analysis of the Toronto Green Development Standard (TGDS). In attempting to achieve this objective, numerous factors had to be considered and reconciled. Chiefly among them is the temporality and extensibility of green development principles and practices. Over time it is reasonable to expect the TGDS to evolve and reflect emerging social, economic and environmental realities. Changes in technology alone require the TGDS to remain a dynamic framework for "building better" and to serve as a ratchet that does not allow the development industry to slip backward to lesser practices. The relationship of Toronto to the Greater Toronto Area and Hamilton (GTAH) and the Greater Golden Horseshoe (GGH) is such that development practices adopted in Toronto tend to extend outward to the GTAH and GGH. Toronto is home to the highest concentration of developers, designers and constructors in Canada and practices adopted by this community tend to rapidly diffuse across neighbouring regions. For these reasons, the development of a cost-benefit matrix was extended beyond the City of Toronto to include the Greater Toronto Area and Hamilton. The time horizon was also extended to consider all new development that would occur in this region from now until 2031 as projected in Places to Grow, and then to examine this mix of buildings over a subsequent useful service life of 75 years on average.

This appraoch assumes that the development which takes place in the GTAH from now until 2031 will exert its social, economic and environmental impacts until at least 2081, at which time it may be assumed the building stock will be substantively retrofit. The cost-benefit matrix considers two scenarios:

- ***Business As Usual*** – Under this scenario, the currently adopted changes to minimum levels of energy efficiency for buildings under the Ontario Building Code are in effect over most of the period leading up to 2031, with incremental improvements in energy efficiency occurring through natural conservation. Environmentally responsible requirements for other than energy efficiency aspects of buildings are assumed to remain non-existent in the Ontario Building Code over this developmet cycle.
- ***Green Development*** – This scenario is premised on the Toronto Green Development Standard as of January 2007 being in effect for all new buildings, and the standard undergoing periodic review and updating in 2011 and 2021. It is assumed the ultimate goal of the standard is to achieve net zero impact development by 2031 – developments that are carbon neutral and extert net zero impact on utility and municipal infrastructure.

The cost-benefit matrix does not account for a larger and much needed assessment of sustainability in the GTAH. The time and resources for research into the absolute social, economic and environmental carrying capacity of the GTAH was limited in this study. Exploration of this topic did not yield definitive results. Can this region sustain population growing from approximately 6 million people today, up to 8.6 million people by 2031? Perhaps the more interesting question seeks to determine the sustainability of the Great Lakes region and identify limits for the intensity and extensiveness of development that is both feasible and desireable. These questions cannot be answered within the limited scope of this study, but it should be recognized that ultimate thresholds for social, economic and environmental systems are self-evident after their collapse, strongly suggesting that sustainability is a field of inquiry and policymaking that should seek alternatives to destructive testing methodologies.

Monetized Costs and Benefits

The assembly of the cost-benefit matrix is broken into two parts. The first deals with monetized costs and benefits that can be economically assessed. The second part focuses on intangibles that have not been, and may well never be, fully monetized.

The sections which follow highlight the resulting cost-benefit assessment according to the categories outlined below:

- ***Energy*** – assessment of energy conservation measures compared to energy savings plus avoided electrical energy generation costs due to reduced demand;
- ***Carbon*** – GHG emission reductions due to improved energy efficiency;
- ***Water*** – assessment of the costs for water conservation measures compared to water savings plus avoided waterworks expansion costs, combined with avoided stormwater management costs associated with landscape infrastructure;
- ***Air*** – assessment of health costs avoided due to improved air quality attributable to lower energy demands in new developments;
- ***Waste*** – assessment of solid waste diversion costs compared to savings in landfill costs plus revenues from renewable energy generation; and
- ***Ecology*** – assessment of the economic costs and benefits associated with the maintenance of healthy urban forests and an unpolluted waterfront.

Energy conservation involves costs associated with improving the energy efficiency of building developments. The benefits are not just savings due to reduced energy costs, but also avoided costs for expansion of electricity generation capacity and lower greenhouse gas emissions. Hence the energy and carbon requirements of the TGDS can be addressed by assessing the energy performance of new developments.

Water involves looking at both efficiency (conservation of potable water and therefore reduced wastewater treatment costs) as well as water quality, specifically the impact of stormwater management on the quality of runoff entering streams, rivers and lakes.

Air quality begins in the outdoors where traffic, fossil-fuel combustion and various other industrial emissions contaminate the air. This is the air that enters our buildings and becomes further contaminated with emissions from occupants, their activities and the materials comprising the building.

Solid waste is viewed by some stakeholders as a resource that can provide feedstock for recycled materials, compost for biogas and fuel for waste-to-energy plants. Currently it poses a landfill cost and liability that can only be minimized, likely never completely eliminated in the near future.

Ecology is the most difficult to assess cost-benefit parameter simply because it is so complex and widespread. It is difficult to ascribe costs and benefits to any particular stakeholder because there is no real cost for operating the ecological assets and services, and the benefits, which are enjoyed by everyone without restriction, cannot be enhanced, only degraded.

Environmental Improvement vs Sustainability

"Analytic and policy approaches to environmental problems can be roughly grouped into two categories. Adherents to environmental improvement take current resource use practices as given and look for marginal improvements. The time frame is immediate or short term and the scale of activity follows political boundaries. 'The environment' is seen as being 'out there,' as separate from humans; it is benign and resilient, indeed bountiful, something to be managed for optimal human use. Environmental improvement is the goal, doing better than present conditions, even if 'better' is only slowing the rate of degradation. Because crises are rare and localized, incremental social change is needed, if at all.

By contrast, there are those who presume current practices are unsustainable, even catastrophic if pursued to their logical conclusions. The starting point for these advocates of sustainability is not the status quo environment but ecological integrity. Their orientation is long term, even very long term, that is, over many generations of key species, including humans. The scale is determined in the first instance by biophysical processes. From this view, human and natural systems may be separate, but the focus is on the intersection of the two systems. Perceived crises demand alternative forms of social organization, ones that make transformational, not marginal, change."

Thomas Princen. ***Principles for Sustainability: From Cooperation and Efficiency to Sufficiency.*** Global Environmental Politics 3:1, February 2003. http://muse.jhu.edu/demo/global_environmental_politics/v003/3.1princen.pdf

Energy Conservation

The demand for energy in the GTAH under the business-as-usual (BAU) scenario is predicted to sharply increase over the next 25 years in response to population growth. Likely the most critical increase to consider in terms of economic impacts is the demand for electricity, but from a resource depletion perspective, natural gas may well prove to be the critical energy source. The current and anticipated electrical generating capacity of the Ontario grid could not absorb fuel switching from natural gas to electricity without a major commitment to renewable energy generation coupled to effective conservation and demand management programs. This assessment of the impacts of the TGDS on energy demand begins with a review of electrical energy data.

Energy Addiction

It's hard to make precise comparisons but it's likely that a key difference between life in Central Ontario today and life here 150 years ago is the amount of energy we use: in the order of 30 times more per person. Civilization as we know it depends on vast amounts of cheap energy, not only from oil but also from natural gas, coal, uranium, and other sources. Each Central Ontario resident now draws on the energy equivalent of 80 'energy slaves' working 14 hours a day, 365 days a year.

Excerpted from, ***Energy and Smart Growth***. Richard Gilbert, Neptis Foundation, Toronto, Ontario, 2003. http://www.neptis.org/library/show.cfm?id=48&cat_id=22

Ontario and Electricity

Understanding the current state of affairs of energy generation, management and cost in Ontario is critical to the analysis of the Toronto Green Development Standard. The Ontario supply matrix is diverse, its pricing structures complex, and the plans to accommodate future population growth are partially tied to Conservation and Demand Management (CDM). This discussion attempts to summarize the current capacity and supply mix in Ontario, outline the forecast demands and the Ontario Power Authority's plans to be able to meet future demand, to identify the costs and benefits of CDM relative to the costs of additional capacity, and finally to identify other relevant issues.

Electricity Forecasts

The OPA forecasts that energy demand in Ontario will grow from 157 TWh (2007) to 195 TWh in 2027. While this represents an increase of 24% over current levels, on an annual basis this 1.1% per year increase is lower than the recent historical rate of increase (1995-2005) of 1.3% per year. Similar to the Places to Grow population projections, OPA also presents a High Growth Scenario where demand grows 1.7% per year and a Low Growth Scenario where demand grows significantly less at 0.4% per year.

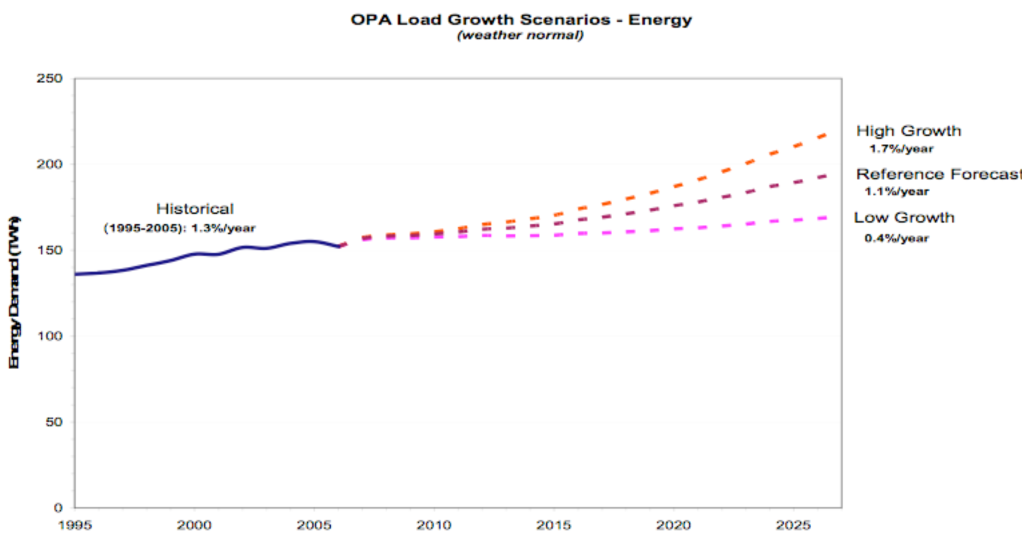

Figure 53. Reference forecast growth scenarios – energy demand.
[Source: IESO/OPA as cited in OPA, 2007, Section D-1-1, p. 26.]

These forecast values represent a "Business as Usual" scenario as they do not assume the effects of the potential impacts of any conservation programs. They do consider the naturally occurring conservation that arises through typical efficiency improvements. These scenarios are complex predictions, but are partially based on Statistics Canada population predictions generated in 2006 and are, therefore, consistent with the vision outlined in the Places to Grow outlook.

Peak demand in Ontario currently stands at 26,282 MW and is expected to reach 33,677 MW by 2027 in the Reference Forecast, corresponding to a 1.2% annual increase and a total increase of 28% over current levels.

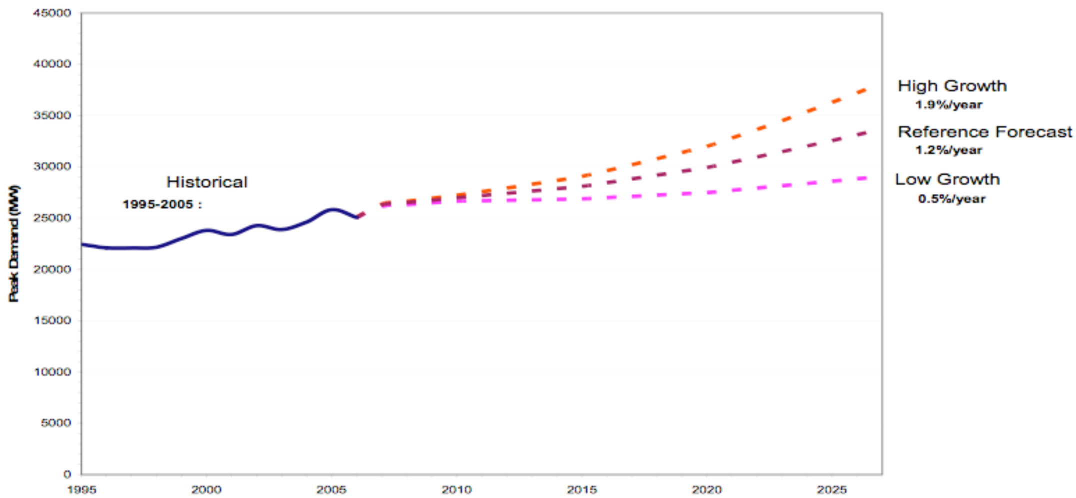

Figure 54. Reference forecast growth scenarios – peak demand.
[Source: IESO/OPA as cited in OPA, 2007, Section D-1-1, p. 27.]

As can be seen from Figure 2, the peak demand is predicted to grow at a faster rate than energy demand. It is unclear whether time of use pricing has been considered in either of the electrical energy and peak electrical power demand forecasts. For the purposes of this study, and lacking any other projections, these various scenarios are assumed to apply to the Ontario of 2031.

Current Supply Capacity and Forecast Demand-Supply Gap

As of June, 2007, current generation capacity is approximately 31,000 MW comprised of approximately 11,400 MW of nuclear generation, 7,800 MW of hydroelectricity, 6,400 MW of coal-fired generation, 5,100 MW of gas/oil generation, 400 MW of wind generation, and a smaller amount of biomass.[98]

Existing resources are not sufficient to meet this future demand. Additionally, the Ontario Government's mandate to eliminate coal-fired generation by the end of 2014, and the approaching end-of-service of some of Ontario's nuclear resources will decrease our capacity by 18,000 MW.[99]

[98] Integrated Power System Plan before The Ontario Energy Board. Ontario Power Authority, August 29, 2007 (corrected October 19, 2007). Section D-3-1: Determining Resource Requirements, p.3.
[99] ibid. p.4.

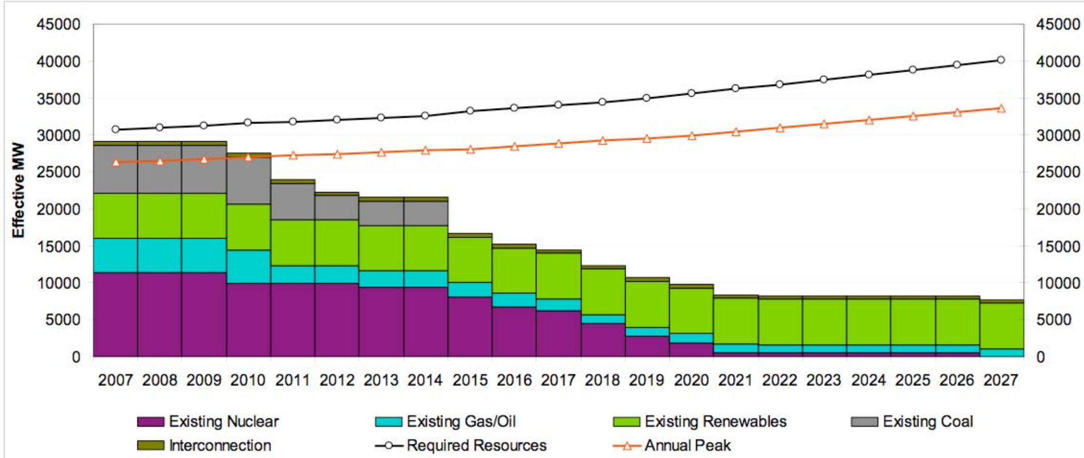

Figure 55. Contribution of existing resources towards resource requirements (effective MW). [Source: OPA, 2007, Section D-3-1, p. 5]

According to the Ontario Power Authority, if no further resources were added (including CDM), the gap between existing supply capacity and demand requirements of 2027 would be 32,000 MW[100].

In Ontario, every additional 1000 MWs of electricity production requires a minimum expenditure of $1.5 to $2.1 billion[101]. Extrapolating this cost to accommodate the gap discussed in the previous section, the cost to meet Ontario's needs in 2027 through additional capacity alone ranges from $48 to $67 billion.

Integrated Power System Plan (IPSP)

The Ontario Power Authority (OPA) has developed an Integrated Power System Plan to assist in managing Ontario's electricity system and to ensure the achievement of the government of Ontario's goals identified in the *Supply Mix Directive* dated June 13, 2006.[102] The plan lays out the current power mix, identifies future system demands and capacities, and proposes investments in generation, transmission and conservation for the 2008 to 2027 timeframe.

The IPSP states that 32,000 MW of effective resources will be added by 2027 with the following breakdown[103]:

- Conservation and renewables – 38%
- Nuclear -36%
- Natural gas-fired and other – 25%.

If the Pickering B nuclear plant is not refurbished, the scenario changes slightly with the additional 2,000 MW will be addressed through additional natural gas-fired resources, procurement outside of Ontario, service extensions to Pickering B, or other.

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[100] Including reserve requirements.
[101] Based on a cost estimate of $18.2 Billion for 12,000 MW additional capacity, and a cost of $26 billion for the equivalent in nuclear capacity. This nuclear estimate only considers construction costs. *Towards a Sustainable Electricity System for Ontario? A Provincial Progress Report.* Pembina Institute, November 2005. p. 2.
[102] *Integrated Power System Plan before The Ontario Energy Board.* Ontario Power Authority, August 29, 2007. Section B-1-1: The IPSP, p.1.
[103] ibid. Section D-9-1: Meeting Resource Requirements.

Installed MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Existing Resources	31,214	31,214	31,214	29,674	26,104	24,428	23,747	23,747	18,837	17,366	16,644	14,506	12,811	11,930	10,534	10,403	10,403	10,403	10,403	10,403	9,888
Committed Resources	773	1,631	5,978	8,602	8,602	9,372	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142	10,142
Planned Nuclear	0	0	0	0	0	0	0	0	516	516	1,032	3,045	4,593	5,990	7,673	9,368	10,249	10,249	10,249	10,249	10,249
Planned Gas	0	0	0	0	2,455	2,905	4,507	5,057	5,361	5,361	5,361	5,361	5,361	4,836	4,836	4,311	4,311	4,311	4,311	4,311	4,311
Planned Renewables	16	36	81	81	855	1,260	1,729	2,335	2,692	3,278	3,380	3,837	4,129	5,599	5,746	6,247	6,247	6,276	6,411	6,411	6,411
Planned Conservation	0	0	0	755	1,084	1,413	1,741	2,070	2,398	2,614	2,878	3,146	3,358	3,560	3,722	3,884	4,043	4,206	4,354	4,583	4,811
Unspecified	0	0	0	0	0	0	0	0	0	0	0	250	250	250	250	250	250	250	250	250	650
Interconnection	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Annual Peak	26,282	26,515	26,749	26,986	27,205	27,426	27,648	27,873	28,099	28,457	28,820	29,187	29,559	29,936	30,444	30,960	31,485	32,020	32,563	33,115	33,677
Required Resources	30,750	31,022	31,296	31,573	31,830	32,088	32,349	32,611	33,157	33,580	34,008	34,441	34,880	35,624	36,228	36,843	37,468	38,103	38,750	39,407	40,076

Table 35. Case 1A existing, committed and planned resources by type: installed MW. [Source: OPA, 2007, Section D-9-1, p. 6]

From the above table it can bee seen that Planned Conservation only represents 4,811 MW in 2027, or 15% of the 32,000 MW of total planned effective resources.

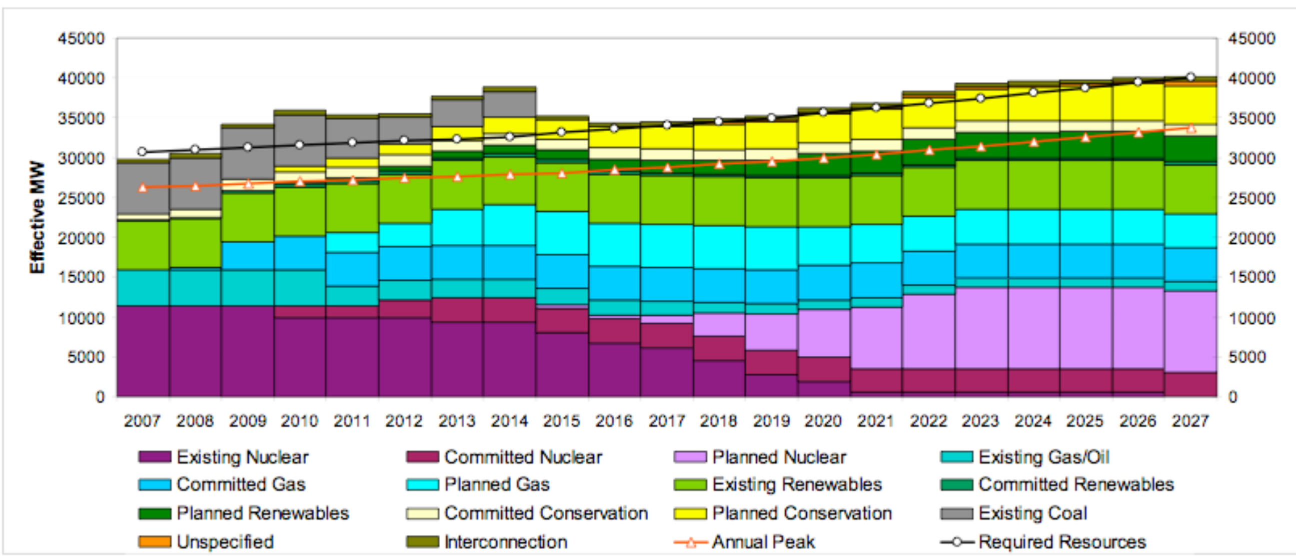

Figure 56. Case 1A cumulative resources: effective MW.
[Source: OPA, 2007, Section D-9-1, p. 6.]

Represented graphically it can be seen that the Planned Conservation portion of the proposed capacity can be roughly equated to the reserve requirements in 2027. The Supply Mix Directive sets specific goals for reducing Ontario's peak energy demand within the timeframe of the IPSP. These targets include a reduction in peak demand of 1,350 MW by 2010 and an additional 3,600 MW by 2025, which, when added to the target of 1,350 MW reduction by 2007, gives a total peak reduction of 6,300 MW.[104]

[104] Supply Mix Directive. Letter from Minister of Energy to the CEO of OPA, June 13, 2006.

Conservation and Demand Management (CDM)
As part of the IPSP, OPA has developed the capacity goals into action plans for installation of new generating facilities, as well as a plan for Conservation and Demand Management. The plans for the CDM portion of the IPSP, which would contribute 4,811 MW to avoided capacity in 2027, can be broken down into the following strategic categories:

- Energy Efficiency
- Demand Management/Conservation Behaviour
- Customer-Based Generation
- Fuel Switching

with the assumptions that 65% of the conservation opportunities would be found in the energy efficiency strategy, and that peak demand reductions will mainly be provided using the Demand Management strategy (approximately 20%)[105].

Demand Side Resource	Contribution by 2020 (MW)	Percentage of Achievable Economic Potential
Fuel Substitution	400	50%
Demand Reduction	1,500	50%
Cogeneration	8,250	50%
Energy Efficiency	2,150	50%
Total	***12,300***	***50%***

* Demand reduction potential could be increased if Smart Meters provide enabling technology.
** Co-generation estimate is conservative – based on economic potential at $50/MWh.

Table 36. Closing the gap between electricity supply and demand in Ontario.
[Source: *The Electricity Supply/Demand Gap and the Role of Efficiency and Renewables in Ontario.* ICF Consulting, for Pollution Probe, 2006, p. 10.]

In a study produced for Pollution Probe, ICF Consulting studied the OPA's CDM plan and compared it with the economic potential of CDM in Ontario. They concluded that even at a conservative estimate of 50% of its achievable economic potential, contributions made by demand side resources could equal over 250% of the MW savings outlined in the IPSP. This potential 12,300 MW of CDM contribution by 2020 is in fact larger than the contribution of Planned Nuclear in 2027 of 10,249 MW.

105 Integrated Power System Plan before The Ontario Energy Board. Ontario Power Authority, August 29, 2007. Section D-4-1: Conservation Resource, p.3.

Avoided Utility Costs

An important concept in the valuation of CDM programs is their benefit as it relates to avoided utility costs. The question to be answered is "Are CDM programs more cost-effective than adding new generating capacity?" A study completed by Navigant Consulting in 2005 developed estimates of the avoided costs to the utility gained by the implementation of CDM measures, taking into account costs up to the point of wholesale delivery.

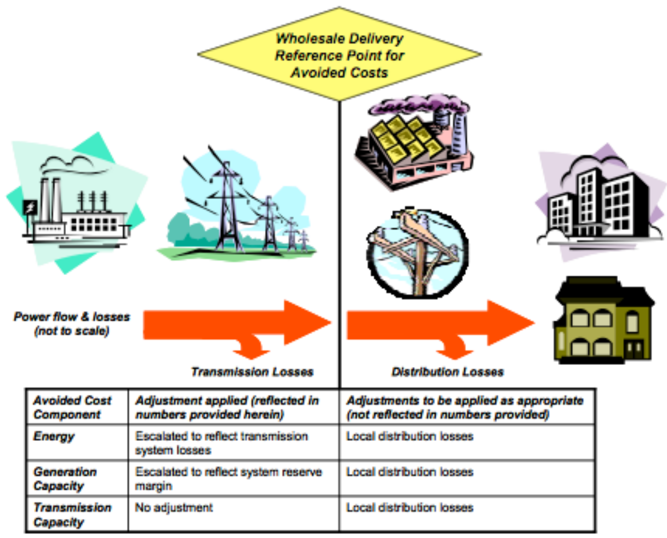

Figure 57. Schematic representation of reference point for avoided costs.
[Source: Navigant Consulting, 2005, p. 44.]

These costs were detailed annually for the period of 2006 to 2025 and are summarized in the following tables.

Year	Ontario Seasonal Average Avoided Energy Cost (2005 CAD$/MWh)								Avoided Generation Capacity Costs (2005 CAD$/kW-yr)	Avoided Transmission Costs (2005 CAD$/kW-yr)
	Winter			Summer			Shoulder			
	On Peak	Mid-Peak	Off Peak	On Peak	Mid-Peak	Off Peak	Mid-Peak	Off Peak		
Hours/Period	602	688	1,614	522	783	1,623	1,305	1,623	N/A	N/A
2006	$117.8	$81.9	$44.3	$110.2	$79.4	$46.3	$82.1	$41.3	$0.00	$0.00
2007	$118.6	$80.2	$43.0	$106.2	$75.7	$43.7	$77.5	$38.9	$0.00	$0.00
2008	$107.2	$80.6	$45.4	$102.7	$77.6	$46.6	$83.9	$41.7	$69.32	$5.22
2009	$101.4	$69.8	$44.3	$94.7	$72.0	$43.1	$77.7	$39.3	$75.71	$5.22
2010	$100.3	$68.4	$46.1	$94.6	$71.2	$42.6	$73.8	$38.4	$63.19	$5.22
2011	$95.0	$66.7	$45.4	$89.0	$70.1	$41.8	$72.6	$37.1	$73.65	$5.22
2012	$94.5	$66.4	$44.8	$95.2	$71.1	$43.1	$74.4	$40.2	$68.31	$5.22
2013	$102.7	$70.9	$49.2	$96.0	$74.9	$44.3	$75.9	$42.6	$50.55	$5.22
2014	$100.7	$74.0	$50.3	$102.4	$77.5	$45.4	$79.2	$43.6	$37.34	$5.22
2015	$99.5	$73.9	$54.4	$118.4	$83.4	$48.8	$80.3	$46.8	$18.10	$5.22
2016	$100.4	$74.2	$54.0	$116.3	$82.4	$48.7	$79.6	$46.8	$20.49	$5.22
2017	$101.1	$74.4	$53.6	$114.1	$81.4	$48.6	$79.0	$46.7	$22.26	$5.22
2018	$101.8	$74.5	$53.2	$112.0	$80.4	$48.4	$78.3	$46.6	$22.97	$5.22
2019	$102.4	$74.6	$52.8	$109.9	$79.5	$48.2	$77.6	$46.5	$22.94	$5.22
2020	$102.8	$74.6	$52.4	$107.9	$78.5	$48.0	$76.9	$46.4	$21.99	$5.22
2021	$102.6	$74.4	$52.5	$105.8	$78.5	$48.2	$77.2	$46.5	$25.78	$5.22
2022	$102.4	$74.1	$52.6	$103.8	$78.5	$48.2	$77.5	$46.7	$27.59	$5.22
2023	$102.1	$73.7	$52.6	$101.7	$78.4	$48.3	$77.6	$46.7	$28.36	$5.22
2024	$101.8	$73.4	$52.7	$99.8	$78.4	$48.3	$77.7	$46.8	$27.88	$5.22
2025	$101.4	$73.0	$52.6	$97.8	$78.2	$48.3	$77.8	$46.8	$25.64	$5.22

Table 37. Avoided energy, generation capacity and transmission capacity costs. [Source: Navigant Consulting, 2005, p. 49.]

A critical distinction is made in this Navigant Consulting report with respect to conservation and demand management: some measures result in conservation and some measures will result in demand management, or peak savings only.

Year	Avoided Capacity Costs (2005 CAD$/kW-yr)
	SCGT Peaking Capacity
2006	$0.0
2007	$0.0
2008	$134.5
2009	$132.9
2010	$131.3
2011	$129.7
2012	$128.1
2013	$126.6
2014	$125.1
2015	$123.6
2016	$122.1
2017	$120.7
2018	$119.2
2019	$117.9
2020	$116.5
2021	$115.1
2022	$113.8
2023	$112.5
2024	$111.2
2025	$109.9

Table 38. Avoided generation capacity costs for demand response programs.
[Source: Navigant Consulting, 2005, p. 52.]

CDM Potential in Ontario

In 2005, OPA commissioned a study to assess the potential of conservation and demand management (CDM) within the context of the Integrated Power System Plan.

In its summary report, ICF Consulting reviews the current potential for energy efficiency in Ontario, analyses CDM programs from other jurisdictions and the potential impact of implementing similar programs in Ontario, and utilizes studies performed by ICF to estimate the "technical, economic and achievable energy savings potential."[106]

Variation in the current diffusion and deployment of energy efficient technologies in Ontario makes the estimation of the technical and economic potential of CDM critical as it defines the theoretical limits of these technologies. *Technical Potential* may be defined as the achievable energy efficiency if the only limit on implementation were the technology, also taking into account the current market saturation of the technology. *Economic Potential* defines the segment of the Technical Potential that is cost-effective when the incremental installation cost of the measure is compared with avoided cost at the utility. This "potential" is useful as an outside boundary limit for actual predictions.

[106] Electricity Demand in Ontario – Assessing the Conservation and Demand Management (CDM) Potential**.** ICF Consulting, Ontario Power Authority, November 2005. p. 1.

Forecast	TW.hours			GW		
	2004 Load	Technical Potential	Economic Potential	2004 Load	Technical Potential	Economic Potential
Residential	46.9	11.5	9.6	6.9	2.9	1.8
Commercial	52.9	16.6	12.4	10.2	3.9	2.3
Industrial	41.9	8.4	7.5	7.4	1.5	1.2
Total	**141.7**	**36.6**	**29.6**	**24.5**	**8.2**	**5.2**

Table 39. Technical and economic potential of CDM programs relative to 2004 electricity loads in Ontario. [Source: ICF Consulting, 2005, p. 10.]

These values indicate a cost-effective potential of 21% improvement in the efficiency of electricity use in Ontario, which, extrapolated to 2027 equates to a potential reduction of 41 TWh. It is interesting to note that the Economic Potential of CDM programs is roughly equivalent to the increase in demand predicted by OPA.[107]
ICF also reviewed twenty-one recent studies investigating the efficiency potential of CDM programs in the US and Canada, in order to gain an understanding of what is actually achievable in a CDM program.

	Technical Potential	Economic Potential	Maximum Achievable Potential	Achievable Potential
Residential Sector	21%–36%	10.6%–30%	11%–35%	5.3%–21.7%
Commercial Sector	18%–41%	12.7%–35%	9%–39%	5.1%–17%
Industrial Sector	17%–38%	6.2%–32%	7%–60%	2%–19%

Table 40. Summary of energy efficiency potential studies.
[Source: ICF Consulting, 2005, p. 15.]

These resulting potentials were applied to the predicted demand horizon in Ontario in three scenarios to demonstrate the relative reductions if the potentials were realized. A similar analysis was undertaken relative to existing energy efficiency programs in North America, but the results were not easily adaptable to an analysis of the potential impacts in Ontario. However, analysis of existing energy efficiency programs revealed an average cost of just under $225,000 per GWh reduction in energy consumption.[108]

[107] ICF Consulting makes a similar observation in their 2005 report, relative to the then projected 2025 demand (170 TWh).
[108] Calculated from table in ICF Consulting, November 2005. p. 19-20. Costs per GWh for 18 programs were averaged (two outliers - MIN=$2,176/GWh, MAX=$1,600,000/GWh – were excluded from the 20 programs studied).

A third method of estimating the "size of the efficiency resource in Ontario"[109] was performed by ICF using their proprietary measure-based Energy Efficiency Potential Model (EEPM). In this method, ICF developed several scenarios, from *Naturally-Occurring/Static Efficiency* (where no efficiency gains are made) to *CDM100 plus Aggressive Standards* (assuming that incentives are equal to 100% of the incremental costs and additional aggressive standards are implanted) to determine the potential of CDM in Ontario from 2005 to 2025.

The program costs and benefits of these CDM scenarios are summarized in the following graph. The results of the ICF investigation indicate that in all cases CDM program benefits greatly exceed cost.

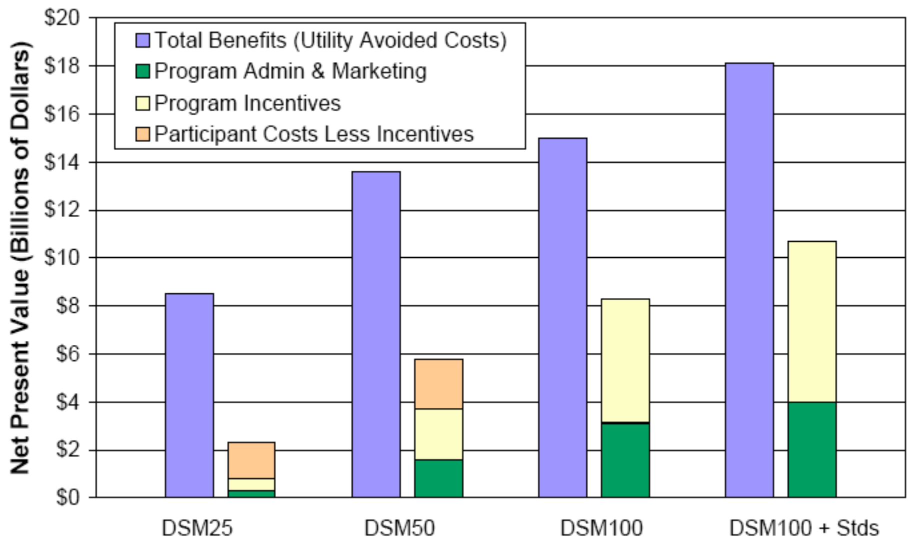

Figure 58. Program costs and benefits for CDM scenarios.[110]
[Source: ICF Consulting, 2005, p. 40.]

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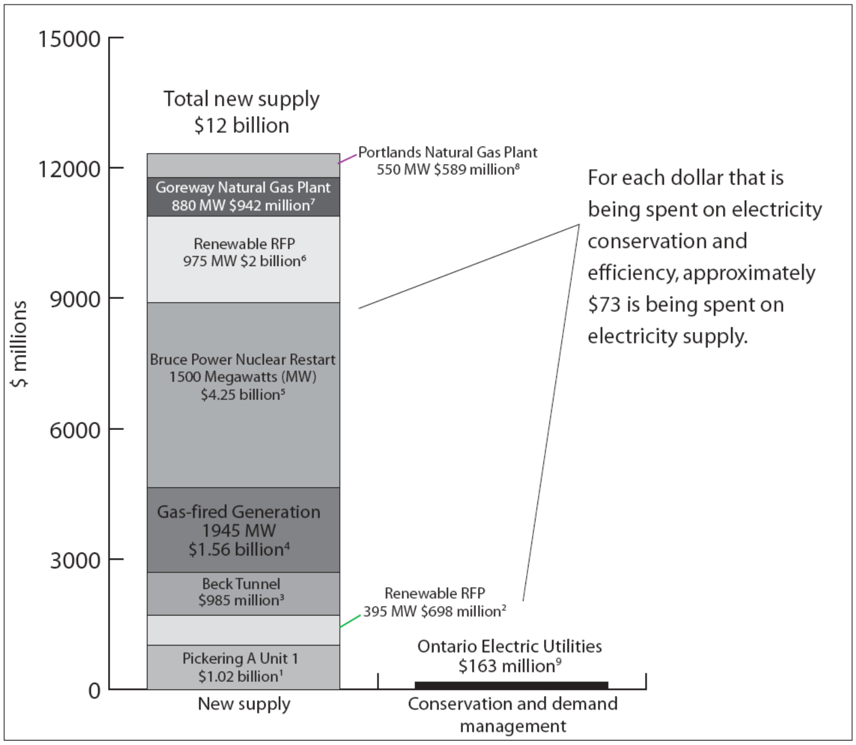
[109] ibid. p. 24.

[110] For all scenarios it was assumed that program administration costs equal 60% of incentive costs. All costs and benefits were converted to present value using a discount rate of 8%. The ICF study contains additional summary graphs including Total Resource Cost, PAC Net Benefits, RIM Net Benefits, and Participant Cost Test Net Benefits.

According to the Pembina Institute, for each $1 spent on Conservation and Demand Management in Ontario, $73 are spent on new supply capacity.[111] Given the various costs associated with developing new electrical energy generation capacity, and the cost effectiveness of conservation and demand initiatives, it is apparent there is a large potential for the funding of renewable energy and energy efficiency programs in Ontario.



1. Ontario Power Generation, News Release, "Ontario Power Generation Reports 2005 Third Quarter Financial Results", (November 11, 2005).
2. Ontario Ministry of Energy, Results of the 300 MW Renewables RFP: Media Pre-Briefing, (November 24, 2004), p. 12
3. Ontario Power Generation, News Release, "Ontario Power Generation Begins Niagara Tunnel Project", (September 14, 2005)
4. Ontario Ministry of Energy, Backgrounder, "Contract Structure and Pricing", May 30, 2005
5. Ontario Ministry of Energy, News Release "Government and Bruce Power Reach Agreement to Restart Nuclear Units (October 17, 2005)
6. Ontario Ministry of Energy, News Release, "McGuinty Government Approves New Green Power Projects", (November 21, 2005)
7. Toronto Star, "Gas power plant on way", (February 3, 2006)
8. Ontario Ministry of Energy, News Release, "Ontario Government Announces Balanced Energy Plan for Toronto", (February 10, 2006)
9. Ontario Energy Board, News Release, "OEB Issues Total Resource Cost Guide for 2005 and 2006 Conservation and Demand Management Plans", (September 8, 2005)

Figure 59. Supply versus conservation spending in Ontario.
[Source: *A Quick Start Energy Efficiency Strategy for Ontario*. Mark S. Winfield, Roger Peters, and Stephen F. Hall, Pembina Institute, April 2006, p. 43.]

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[111] *A Quick Start Energy Efficiency Strategy for Ontario*. Mark S. Winfield, Roger Peters, and Stephen F. Hall, Pembina Institute, April 2006.

Electricity Pricing
While not directly related to this study, it is interesting to examine the effects of electricity pricing on demand. The Ontario Energy Board is planning to have smart meters and time of use rates in place for implementation by 2010. A recent pilot found that while consumers were able to realize energy savings by modifying their time use of electricity, this tended to result in an average conservation of approximately 6% of consumption and a slightly smaller reduction in peak demand.[112]

Time	Summer Hours (May 1 to Oct 31)	Price/ kWh	Winter Hours (Nov 1 to Feb 28)	Price/ kWh
Off-Peak	10 pm – 7 am weekdays; all day on weekends and holidays	2.7¢	10 pm – 7 am weekdays; all day on weekends and holidays	2.7¢
Mid-Peak	7 am – 11 am and 5 pm – 10 pm weekdays	7.3¢	7 am – 11 am and 8 pm – 10 pm weekdays	7.3¢
On-Peak	11 am – 5 pm weekdays	9.3¢	7 am – 11 am and 5 pm – 8 pm weekdays	9.3¢
Source: Ontario Energy Board http://www.oeb.gov.on.ca				

Table 41. Ontario Energy Board schedule of time of use electricity rates planned for implementation in 2010, effective May 1, 2008.

Time of use rates are only one aspect of the complex challenge associated with changing our energy patterns and reducing energy consumption. In Ontario there is energy policy that inhibits conservation and innovation through the regulation of electricity pricing; current energy prices in Ontario are artificially low due to subsidies in the order of $7.9 billion, reducing our energy costs from roughly $21 billion to roughly $13 billion.[113]

Subsidy	Value
Subsidy #1 - Below-Market Water Royalty Rates	$1.9 billion
Subsidy #2 - OPG's Below-Market Return on Equity	$0.851 billion
Subsidy #3 - Corporate Income Tax Revenue Subsidy for Nuclear Debt	$0.949 billion
Subsidy #4 - Sales Tax Exemption	$1.085 billion
Subsidy #5 - Northern Pulp and Paper Electricity Transition Program	$0.047 billion
Subsidy #6 - Public Health and Environmental Subsidy for Coal-Fired Generation	$3.1 billion
Subsidy #7 - Subsidies for Nuclear Reactor Decommissioning and Long-Term Storage of Radioactive Nuclear Wastes	Unknown
Subsidy #8: - Nuclear Liability Act	Unknown
Subsidy #9: Average Cost Pricing	Unknown
Subsidy #10: Bulk Metering	Unknown
TOTAL	$7.932 billion

Table 42. Summary of subsidies for grid-supplied electricity.
[Source: Ontario Clean Air Alliance Research Inc., February 2008, p. 2.]

[112] *Ontario Energy Report Smart Price Pilot*. Ontario Energy Board, July 2007. http://www.oeb.gov.on.ca/documents/cases/EB-2004-0205/smartpricepilot/OSPP%20Final%20Report%20-%20Final070726.pdf
[113] *Tax Shift: Eliminating Subsidies and Moving to Full Cost Electricity Pricing - An OCAA Research Report*. Jack Gibbons and Jessica Fracassi. Ontario Clean Air Alliance Research Inc. February 19, 2008. p. 5.

According to a report prepared by the Ontario Clean Air Alliance Research Inc., these subsidies are:[114]

- *“Promoting excessive electricity consumption;*
- *Lowering our electricity productivity;*
- *Lowering our standard of living; and*
- *Promoting excessive air pollution.*”

It is a universal truth that the price of electricity is elastic: the cheaper it is, the more we consume. Certainly there is a minimum quantity of energy consumption required to maintain an acceptable quality of life in Ontario, but beyond that minimum, there must be an incentive to conserve. Electricity consumption per capita in Ontario is 52% higher than that of New York State, and this is likely due in large part to subsidization.[115] Full cost electricity pricing could provide impetus for conservation and innovation in Ontario.

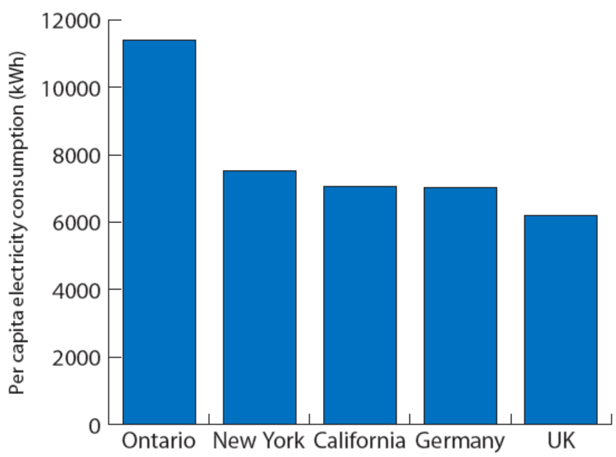


Figure 60. Per capita electricity consumption in 2004.
[Source: Ontario Clean Air Alliance Research Inc., February 2008, p. 6.]

[114] Tax Shift: Eliminating Subsidies and Moving to Full Cost Electricity Pricing - an OCAA Research Report. Jack Gibbons and Jessica Fracassi. Ontario Clean Air Alliance Research Inc. February 19, 2008. p. 6.
[115] Ontario Clean Air Alliance Research Inc. February 19, 2008, p. 6.

Electricity productivity, defined as the GDP per kWh, is another comparative measure used in the Ontario Clean Air Alliance Research study to analyze the impacts of subsidized energy prices in Ontario. The following figure clearly demonstrates that for a given jurisdiction, a higher average price per kWh corresponds to a higher GDP per kWh.

Faulty Fossil Futures?
Natural gas prices and electricity prices influence each other. When natural gas prices go up, the cost and price of electricity goes up, and vice versa. Gas-fired power generators have options to decrease the risk of gas price volatility, but these instruments come at a premium. In other words, volatility can be contained, but only by pushing up the price of natural gas even further. Finally, the option of using natural gas as a "transition fuel" also poses risks. That is because the pipelines required to transport natural gas from its source to power plants are expensive. High pipeline costs have to be spread out by building several gas-fired power plants that last a generation or more. Instead of committing to such problematic transition, Ontario can emulate the development path of world leaders such as Germany, Spain, and Japan and actively develop the best available renewable technologies.

Smart Generation: Powering Ontario With Renewable Energy. The David Suzuki Foundation, 2004. http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

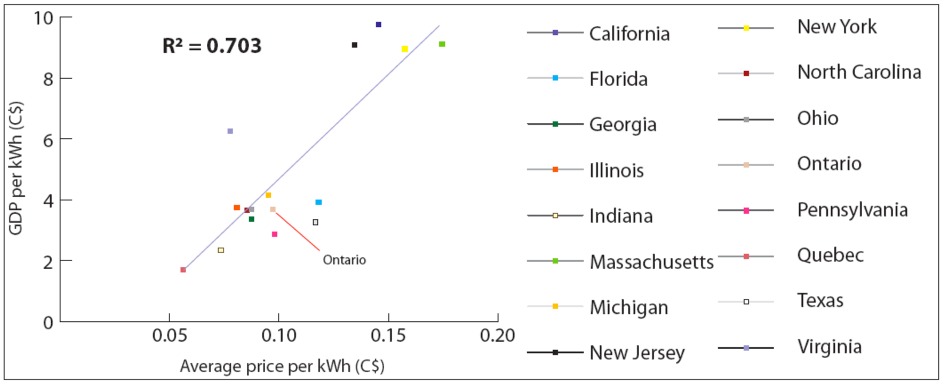


Figure 61. Relationship between electricity prices and electricity productivity. [Source: Ontario Clean Air Alliance Research Inc., February 2008, p. 7.]

Ontario and Natural Gas

Unlike electricity production, natural gas energy essentially involves resource extraction and transportation of the natural gas to connected customers. Issues of capacity matter for the most part only in so far as there are proven reserves of natural gas. According to the Suzuki Foundation, price increases and price volatility are the two unresolved issues with increasing reliance on natural gas in Ontario's energy mix[116].

Natural gas is primarily used as a source of heating energy in new and existing developments. Expansion of conventional electricity generation capacity to permit switching over our buildings from natural gas to electricity is highly unlikely in the first 25 years of the Places to Grow directive. The only two options that are realistic appear to be energy conservation and renewable energy generation. This part of the energy related cost-benefit matrix shall only consider energy conservation costs and benefits in the case of natural gas utilization. Only for the case of electricity will the avoided cost of electrical energy generation capacity also be examined.

How does all of this information relate to the Toronto Green Development Standard? Without energy, civilization as we know it would cease to exist. It would not be possible to produce sufficient quantities of potable water to satisfy basic demands, and the production, transportation and refrigeration of food would cease at the scale needed to support the GTAH. Buildings would not be actively conditioned and our telecommunications systems would no longer function. The conservation of energy and the promotion of renewable energy is central to the requirements of the TGDS. The level of energy conservation and renewable energy implementation must be achievable, cost effective and forward thinking. To continuously evolve effective requirements, their impacts on the entire energy system serving Ontario and the GTAH must be comprehended.

[116] *Smart Generation: Powering Ontario With Renewable Energy*. The David Suzuki Foundation, 2004. http://www.davidsuzuki.org/files/Climate/Ontario/Smart_Generation_full_report.pdf

Costs and Benefits of Energy Conservation

To assemble the energy conservation component of the cost-benefit matrix, there are essentially four steps:

1. Estimate the type and number of building developments that will be constructed between 2007-2031 according to the Places to Grow directive;
2. Review and estimate the energy performance of the forecast building developments according to the business as usual (BAU) and Toronto Green Development Standard;
3. Calculate the energy consumption and greenhouse gas emissions by fuel type, associated energy costs and peak electrical energy costs for the forecast building developments; and
4. Perform a net present value evaluation of the two scenarios.

Forecast Building Development

Buildings are broken down into two major categories: residential and non-residential. Residential buildings are commonly referred to as dwellings that consist of single-detached, semi-detached, row and apartment types. Non-residential buildings comprise commercial, institutional and industrial types. In this study a number of sources of information were accessed to perform an estimation of the number of buildings that currently exist and will be constructed by 2031. The total forecast value in 2007 dollars of new development was estimated as $231.5 billion (see Table 6) using statistical data related to the value of building permits.

Building Type	$/ft^2	$/m^2
Apartments	$190.00	$2,044
Rows	$175.00	$1,883
Doubles	$175.00	$1,883
Singles	$200.00	$2,152
Residential (Blended)	$193.55	$2,082
Commercial	$165.00	$1,775
Institutional/Governmental	$300.00	$3,228
Industrial	$150.00	$1,614

Table 43. Typical unit costs of various building types constructed in the GTAH.
[Sources: *Schedule of Unit Costs*, Toronto Real Estate Board, 2007. *Hanscomb Yardsticks for Costing*, R.S. Means Company, 2007.]

Applying the typical unit costs from Table 43 to the forecast permit values resulted in an estimate of the gross floor areas of the various building types. It should be noted that while the number of dwellings was forecast (see Table 7) it was not possible to deduce the gross floor areas – a vital statistic for estimating energy consumption.

Estimate of Energy Intensities

Looking first at the housing stock, it was necessary to determine the energy consumption under each of the two scenarios. For the BAU scenario, it was assumed the provisions of the Ontario Building Code would come into effect as legislated by 2012 and that for two subsequent 10-year periods, the energy efficiency would increase by 10% during each period in this timeframe. The energy performance of the housing stock was broken into two categories: high-rise to account for condos and large apartment buildings; and low-rise to account for single-detached, semi-detached and row houses.

The relationship between the EnerGuide for Houses rating and the average annual energy consumption per household is represented in Table 44. It is important to note that the EnerGuide for Houses rating scale is non-linear, and reflects the diminishing effectiveness of energy conservation measures on energy consumption in housing. Houses built to satisfy the energy efficiency requirements of the TGDS would be constructed to the Energy Star for New Homes standard and achieve an EnerGuide rating of approximately 80.

This review of housing stock numbers and composition indicates that the diffusion effect of the TGDS is especially important to improving the energy efficiency of the existing housing stock which often consumes between 2 and 3 times as much energy as Energy Star houses. The existing housing stock represents a greater potential for reducing energy consumption and greenhouse gas emissions than houses built under the TGDS.

Average Energy Consumption per Household, Pre-1946 to 2000-2004		
Year Built	***Average Energy Consumption (GJ)***	***EGH Rating***
Pre-1946	295	45
1946-1960	220	58
1961-1970	211	61
1971-1980	202	63
1981-1990	191	66
1991-2000	167	70
2001-2004	156	73
All EGH in Canada	216	60
R-2000	100	82

Table 44. Estimate of average annual household energy consumption and EnerGuide for Houses (EGH) rating by year of construction.
[Source: Appendix 2: Improving Energy Performance in Canada – Report to Parliament Under the Energy Efficiency Act - 2003-2004, Office of Energy Efficiency, Natural Resources Canada.
http://www.oee.rncan.gc.ca/corporate/statistics/neud/dpa/data_e/parliament03-04/appendix2.cfm?attr=0#graph8]

For the Toronto Green Development Standard scenario, it was necessary to make assumptions regarding its evolution over the 2007-2031 period. The most recent study forecasting building energy efficiency potential in Canada was performed by Natural Resources Canada in 2007, and the results are summarized in Table 45.

Table 45. Energy intensities of feasible building technology platforms – Toronto.				
Energy Intensity	***ekWh/m^2.yr***			
Building Type	**2007**	**2012**	**2020**	**2030**
Large Office	241.6	156.4	96.5	58.4
Small Office	251.9	163.8	99.3	9.1
Big Box Retail	425.4	276.2	169.9	0
Warehouse	150.8	97.3	59.6	0
School	291.7	188.9	116.8	31.3
Extended Care	519.2	337.1	207.4	69.6
MURBs	229.4	148.1	92.9	39.5
Source: *Built Environment Strategic Roadmap: Commercial Buildings Technology Review*. Natural Resources Canada, April 2007.				

The Commercial Buildings Technology Review for the Built Environment Strategic Roadmap (BESR) is an overview study of the potential for energy end-use reduction in commercial buildings across Canada. By reviewing the performance of a representative sample of commercial buildings in eight representative Canadian cities an understanding will be developed about the state of energy efficiency in commercial an institutional construction. That understanding will be used to propose a series of technologies that should be supported to enable the achievement of Canadian climate change mitigation goals.

Seven building types were selected and simulations run for eight cities to demonstrate three levels of energy performance targets. For 2012 a performance level equal to a 25% reduction from the Model National Energy Code for Buildings (MNECB) level was selected. For 2020 the reduction was increased to 60%. For 2030 a target of net zero energy was adopted. The net zero energy target applied to all forms (both thermal and electrical) of purchased energy at the building site. The building types are: large offices; small offices; big box retail stores; warehouses; schools; extended care homes; and multi-unit residential buildings (MURBS).

The results of the simulations showed that, by extrapolating from the conditions under which the architecture, engineering and construction (AEC) industries formulate high performance designs in 2007, there are no foreseeable systemic barriers that would prevent industry from achieving 2012 and 2020 targets. The construction approaches used for the 2012 and 2020 target archetypes were generally consistent with projects reviewed under CBIP and C-2000. However, the demand reduction demonstrated was not sufficient to allow the majority of the building types to achieve the 2030 net zero energy target.

The fact that the 2030 target is not systematically attainable indicates that additional development of industry capacity for energy design, simulation and integrated design processes in the architecture, engineering and construction markets is required.[117]

This progressive improvement in energy efficiency based on feasible technology platforms was assumed to reflect the future evolution of energy efficiency requirements in the TGDS. The specific energy intensity values for each building type are summarized in Table 46.

[117] Pope, Stephen. *Built Environment Strategic Roadmap: Commercial Buildings Technology Review*. CETC Sustainable Buildings and Communities Group, Natural Resources Canada, April 2007.

Table 46. Energy intensities used to estimate energy conservation potentials in various building types.

	ekWh/m².yr			
Business As Usual	**2007**	**2012**	**2020**	**2030**
Apartments	229.4	172.1	154.8	139.4
Rows	162.0	121.5	109.4	98.4
Doubles	178.0	133.5	120.2	108.1
Singles	202.0	151.5	136.4	122.7
Residential (Blended)	193.4	145.1	130.6	117.5
Commercial	333.5	250.1	225.1	202.6
Institutional/Governmental	291.7	218.8	196.9	177.2
Industrial	150.8	113.1	101.8	91.6
	ekWh/m².yr			
Green Development Scenario	**2007**	**2012**	**2020**	**2030**
Apartments	229.4	148.1	92.9	39.5
Rows	162.0	105.3	66.0	28.1
Doubles	178.0	115.7	72.5	30.8
Singles	202.0	131.3	82.3	35.0
Residential (Blended)	193.4	125.7	78.8	33.5
Commercial	333.5	216.3	133.2	29.2
Institutional/Governmental	291.7	188.9	116.8	31.3
Industrial	150.8	97.3	59.6	0.0

In order to estimate the cost of energy and the greenhouse gas emissions, it is necessary to establish the proportion of the average energy intensity values that comprise electricity and natural gas sources. The values used for this analysis are summarized in Table 47.

Table 47. Proportion of energy consumption by fuel type.

Building Type	Electricity	Natural Gas
Apartments	0.611	0.389
Rows	0.233	0.767
Doubles	0.233	0.767
Singles	0.233	0.767
Residential (Blended)	0.233	0.767
Commercial	0.893	0.101
Institutional/Governmental	0.752	0.248
Industrial	0.893	0.101

Proportions obtained from energy simulation results for typical buildings and as reported by Natural Resources Canada.

Energy Consumption, Costs and Greenhouse Gas Emissions

The results of estimating annual energy use, energy costs and greenhouse gas emissions are summarized in Table 48 according to the two future scenarios. The energy costs and emission intensities were based on values listed in Table 49.

Business As Usual	2007 - 2011			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,060,208	814,985	$60,671,122	207,685
Residential (Low-Rise Blended)	18,287,775	3,095,298	$162,606,337	658,989
Commercial	7,238,654	2,112,330	$191,234,419	601,788
Institutional/Governmental	2,519,011	642,946	$53,117,038	173,898
Industrial	3,100,037	409,050	$37,032,294	116,535
Total	**35,205,685**	**7,074,609**	**$504,661,209**	**1,758,895**
Green Development	**2007 - 2011**			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,060,208	766,364	$57,051,559	163,159
Residential (Low-Rise Blended)	18,287,775	2,918,424	$153,314,546	621,332
Commercial	7,238,654	1,989,906	$180,151,096	566,910
Institutional/Governmental	2,519,011	605,318	$50,008,421	163,721
Industrial	3,100,037	384,560	$34,815,127	109,558
Total	**35,205,685**	**6,664,572**	**$475,340,749**	**1,624,680**

Business As Usual	2012 - 2021			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,669,239	763,175	$56,814,172	194,483
Residential (Low-Rise Blended)	21,030,941	2,898,526	$152,269,219	617,096
Commercial	8,324,452	2,325,071	$210,494,457	662,396
Institutional/Governmental	2,896,863	707,700	$58,466,683	191,412
Industrial	3,565,042	383,046	$34,678,098	109,127
Total	**40,486,537**	**7,077,519**	**$512,722,629**	**1,774,514**
Green Development	**2012 - 2021**			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,669,239	562,643	$41,885,668	119,787
Residential (Low-Rise Blended)	21,030,941	2,151,113	$113,005,132	457,972
Commercial	8,324,452	1,454,698	$131,697,398	414,433
Institutional/Governmental	2,896,863	442,785	$36,580,754	119,760
Industrial	3,565,042	279,678	$25,319,901	79,678
Total	**40,486,537**	**4,890,917**	**$348,488,853**	**1,191,630**

Business As Usual	2012 - 2031			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,263,218	627,131	$46,686,428	159,814
Residential (Low-Rise Blended)	19,202,164	2,381,832	$125,125,576	507,092
Commercial	7,600,587	1,625,438	$147,154,886	463,076
Institutional/Governmental	2,644,961	494,747	$40,873,561	133,814
Industrial	3,255,039	314,764	$28,496,350	89,674
Total	**36,965,969**	**5,443,912**	**$388,336,801**	**1,353,470**
Green Development	**2012 - 2031**			
	m^2	Annual MWh	Annual Cost	Annual CO_2e (T)
Apartments (MURBs, Condos)	4,263,218	282,225	$21,010,087	60,086
Residential (Low-Rise Blended)	19,202,164	1,078,573	$56,661,032	229,628
Commercial	7,600,587	617,168	$55,873,709	175,827
Institutional/Governmental	2,644,961	195,859	$16,180,939	52,974
Industrial	3,255,039	97,000	$8,781,663	27,635
Total	**36,965,969**	**2,270,825**	**$158,507,430**	**546,149**

Table 48. Forecast building areas, annual energy consumption, costs and greenhouse gas emissions by building type for the GTAH 2007-2031.

Energy Source	Cost	Emission Intensity
Electricity	$97.00	298 kg CO2e
Natural Gas	$39.00	187 kg CO2e
Energy prices based on 2007 schedules obtained from Enbridge and Toronto Hydro. Emissions associated with energy purchased from the Ontario electrical grid were estimated as 0.298 kg eCO_2/kWh and natural gas was taken as 0.187 kg eCO_2/kWh. Note that actual emissions for electricity vary according to time of use and often reflect the use of coal-fired generation to satisfy peak demands.[118]		

Table 49. 2007 Energy Costs and Greenhouse Gas Emissions per MWh

Based on peak demands estimated during the energy conservation measure building simulations, peak demand reductions were calculated for the MURBs and commercial building types only. The averaged difference in peak electrical demand reduction between the two scenarios for the period 2007 – 2031 was estimated as .0051 kW/m2 for MURBs and .0086 kW/m2 for commercial buildings. The total avoided cost was thus conservatively estimated as having a net present value of $990,614,337 in avoided electrical generation expansion costs, based on $1,500 per kW for new generation capacity. Data from Tables 37 and 38 were also considered to account for avoided transmission costs. It is reasonable to assume the reduction in peak demand from low-rise residential buildings, institutional and industrial buildings could easily double the avoided costs. However, future changes to the time of use electricity rates may account for similar reductions among high peak energy demand consumers, hence it was viewed as a fair compromise to underestimate the impacts of green development on avoided costs for electrical energy capacity.

> ***Low Emission Future***
> *Reducing our own GHG emissions means that Canada is facing a transition to a low emissions society – a transition that will be driven by environmental, economic and social factors. We have a substantial national interest in understanding and anticipating the nature and scope of that change and in proactively seeking to manage our response, with respect to both mitigation and adaptation measures, in a way that benefits Canada.*
> ***Getting to 2050: Canada's Transition to a Low-Emission Future: Advice for Long-Term Reductions of Greenhouse Gases and Air Pollutants***. National Round Table on the Environment and the Economy, 2007.
> http://www.nrtee-trnee.ca/eng/publications/getting-to-2050/Getting-to-2050-low-res-eng.pdf

The cost of greenhouse gas emissions was estimates as $30 per tonne in 2007 dollars. This value was held constant over all of the study periods considered, recognizing it may be lower than the actual externality cost associated with greenhouse gases in the future. This cost reflects the only jurisdiction in Canada to place a value on emissions. According to Tory's LLP:

On February 19, the provincial government of British Columbia announced, as part of its 2008 budget, that it plans to introduce legislation that would impose a broad tax on the purchase or use in B.C. of gasoline, diesel fuel, natural gas, home heating fuel, propane, coal and possibly other fossil fuels. According to the government, this new tax, which would take effect on July 1, 2008, would be revenue neutral and among the broadest and most comprehensive in the world.

The tax would be phased in, starting at a rate of $10 per tonne of carbon dioxide equivalent (CO2e) emissions released from the burning of each particular fossil fuel. This initial rate would translate to a tax of $0.0241 per litre of gasoline purchased or used in B.C.; $0.0276 per litre of diesel fuel; $0.4988 per gigajoule of natural gas; $0.0276 per litre of heating fuel oil; $20.79 per tonne of Canadian bituminous coal; and $17.72 per tonne of sub-bituminous coal. Although the initial price per tonne of CO2e is lower than that advocated in many jurisdictions, the tax rate would increase to $15 per tonne on July 1, 2009; $20 per tonne on July 1, 2010; $25 per tonne on July 1, 2011; and $30 per tonne on July 1, 2012. For gasoline, the 2012 rate would translate to a tax of approximately 7.24 cents per litre.

[Source: *Torys On Climate Change*. February 20, 2008. http://www.torys.com/Publications/Documents/Publication%20PDFs/CCB2008-3.pdf]

[118] *The University of Toronto Greenhouse Gas Inventory - Buildings*. Sustainable Technology Group, University of Toronto, February 2007. http://www.sustainability.utoronto.ca:81/ghg-inventory/U%20of%20T%20GHG%20Inventory%20Report%20-%20Buildings%20(Feb%202007).pdf

The economic assessment of costs and benefits associated with energy efficiency and conservation is summarized in Table 50. Analyses have been extended over what is considered the useful life of the building stock, approximately 75 years on average before major retrofitting is required. The cost of green development was taken as the midpoint of the 2% to 7% range reported in other cost-benefit studies. Assuming a reference scenario for population growth across the GTAH from 2007-2031, building permit values were forecast to be valued at $231,556,687,000. The green development premium of 4.5% translated into a net present value of $10,420,050,925. To put that amount into perspective, the development industry would invest an additional $92.50/m^2 ($8.60 ft^2) of building floor area, for a forecast 112,658,190 m^2 of gross building floor area to be constructed over the next 25 years.

Table 50. Net present value of energy costs and greenhouse gas emissions associated with future development scenarios for the GTAH from 2007-2031.

	2007-2031		2032-2056		2057-2081	
	Net Present Value		Net Present Value		Net Present Value	
	Energy Cost	GHG*	Energy Cost	GHG*	Energy Cost	GHG*
Business As Usual (BAU)						
Current	$25,383,815,331	40,074,312	$82,222,185,292	122,171,970	$195,995,691,949	122,171,970
High	$32,747,504,666	$1,202,229,361	$140,821,052,311	$3,665,159,103	$508,226,968,062	$3,665,159,103
Toronto Green Development Standard (TGDS)						
Current	$14,337,869,552	25,501,197	$62,943,417,401	84,061,495	$146,815,766,747	84,061,495
High	$17,982,328,226	$765,035,899	$110,858,137,316	$2,521,844,858	$394,153,893,825	$2,521,844,858

* The quantity of greenhouse gas emissions is not influenced by energy price escalations. In the above table, the first entry indicates the tonnes of GHG emissions for the given time period, and the second entry indicates the net present value assuming an average value of $30 per tonne.

Based on energy savings alone, the green development scenario is more cost effective than the business as usual model. Looking just at the first 25 years for the period 2007-2031, under the current energy price escalation scenario, the net present value of savings is $11,045,945,779, while under the high scenario, this increases to $14,765,176,440. Greenhouse gas emission savings are valued at $437,193,462. Considering the next 25 years thereafter, from 2031 to 2056, the savings grow to approximately $20 billion under the current scenario, and some $31 billion under the high energy price escalation scenario. In addition to the above savings, it has been conservatively estimated that approximately $1 billion in avoided costs are associated with the green development path.

Looking at the useful life of the building assets forecast to be developed from 2007 to 2031, the present value of savings due to energy conservation and reductions of greenhouse gas emissions alone is approximately $50 billion under the current energy price escalation scenario, and some $115 billion under the high scenario.

If the green development path is not taken, these savings translate into the burdens that we place on the shoulders of successive generations. For every $1 invested in energy conservation, anywhere from $5 to $12 is returned over the useful life of the building assets.

TGDS and Existing Buildings

In order to project the costs & benefits of implementing the TGDS, it is important to understand the status quo. As part of this study, an estimate of the current number of buildings in the GTAH was calculated using various sources. Statistics on the number of existing residential buildings in the GTA+ Hamilton, and the Greater Golden Horseshoe regions were not readily available and it was therefore necessary to estimate these totals based on available information and resources.

Buildings are broken down into two major categories: residential; and non-residential. Residential buildings are commonly referred to as dwellings that consist of single-detached, semi-detached, row and apartment types. Non-residential buildings comprise commercial, institutional and industrial types. In this study a number of sources of information were accessed to perform an estimation of the number of buildings that currently exist and will be constructed by 2031.

Residential Building Stock

The residential building stock in the Greater Golden Horseshoe is complex in its diversity and geography. For the purposes of this study, an analysis of existing dwellings in this region with a focus on the urban context is appropriate. This analysis used data sources from both Statistics Canada and the Canada Mortgage and Housing Corporation.

2006 Census

Statistics Canada conducted a Census of Population on May 16th, 2006. In its analysis of Housing and Shelter Costs, the 2006 Census aggregated data examining the Structural Types of Dwellings in Canada. This data set was taken on a 20% sample basis, meaning that a random sample of one in five households was extrapolated to provide an estimate for the entire population. These data were available on a national and provincial level, but also at an urban level, as represented by sets for each Census Metropolitan Area and Census Agglomeration.

From the Statistics Canada website:

"*A census metropolitan area (CMA) or a census agglomeration (CA) is formed by one or more adjacent municipalities centred on a large urban area (known as the urban core). The census population count of the urban core is at least 10,000 to form a census agglomeration and at least 100,000 to form a census metropolitan area. To be included in the CMA or CA, other adjacent municipalities must have a high degree of integration with the central urban area, as measured by commuting flows derived from census place of work data*."

Data sets for fifteen CMAs/CAs within the Greater Golden Horseshoe (GGH) region were consolidated to develop a picture of the total number of residences, as well as a breakdown of the types of dwellings within the region. Further investigation was conducted to allow this data to be updated to reflect the building stock at the end of 2007.

CMHC Completion Data

The Canada Mortgage and Housing Corporation produces monthly completion data for numerous CMAs and CAs across the country, allowing for a more accurate depiction of the current building stock in these regions (as of December 31, 2007). The summary presented in Table 50 may be viewed as a representative best estimate of urban residential dwellings in the GGH. This estimate was compared to gross statistical data obtained from the Municipal Property Assessment Corporation and indicates good agreement. The data obtained from MPAC have been withheld from this study for reasons of confidentiality required by Ontario Regulation 282/98.

CMA/CA	Single-Detached House	Semi-Detached House	Row House	Apartment in Building (< 5 storeys)	Apartment in Building (≥ 5 storeys)	Total Dwellings
Toronto	775,219	144,219	159,027	207,278	489,157	1,800,760
Oshawa	80,721	7,506	11,251	9,896	9,474	118,875
Hamilton	155,773	8,915	33,299	22,838	42,949	266,215
GTA+H	**1,011,713**	**160,640**	**203,577**	**240,013**	**541,579**	**2,185,850**
St Catharines	106,583	8,565	8,744	17,924	9,677	156,125
Kitchener	96,623	11,608	18,967	24,023	17,500	169,090
Peterborough	33,489	1,001	2,452	5,533	2,597	46,600
Barrie	46,395	2,397	5,142	5,305	3,391	63,570
Brantford	32,912	2,735	3,444	4,188	3,796	47,815
Guelph	27,695	1,965	5,205	5,875	5,090	48,755
Centre Wellington	7,300	360	385	1,185	-	9,370
Midland	10,325	470	365	1,635	470	14,010
Orillia	10,750	365	1,060	2,370	740	16,120
Kawartha Lakes	24,775	525	475	2,225	650	29,375
Port Hope	4,730	245	295	575	310	6,285
Cobourg	4,490	420	600	1,250	355	7,300
OUTER RING	**406,067**	**30,656**	**47,133**	**72,088**	**44,575**	**614,415**
TOTAL GGH	**1,417,779**	**191,296**	**250,710**	**312,101**	**586,154**	**2,800,265**

Sources:

- Statistics Canada, 2006 Census of Population, catalogue no. 97-554-XCB2006026. Household Type (11), Structural Type of Dwelling (10) and Housing Tenure (4) for Private Households of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 20% Sample Data
  Geography = Census Agglomerations
- CMHC, monthly completion statistics.

Table 51. Estimate of residential dwellings in the Greater Golden Horseshoe.

Notes on Estimate Methodology

1. Does not include movable dwellings (mobile homes, tents, boats, etc.)
2. Based on data from 2006 Census, with the addition of completion data from census date (06/16/06) to 12/31/07. Completion numbers for the month of May 2006 were halved to estimate the number of completions in the latter part of the month.
3. CMHC, monthly completion statistics were available for the following CMAs/CAs: Toronto, Oshawa, Hamilton, St. Catharines, Kitchener, Brantford, Barrie, Peterborough
4. CMHC, monthly completion statistics were available for the following types of dwelling: single detached, semi-detached, row, and apartment. The data for the first three categories was added directly to the census data, while the apartment completions were divided between the categories of “apartment in building with less than five storeys” and “apartment in building with five or more storeys”. This split was made based on the ratio of these types in the 2006 Census. For example:

Kitchener	**Apartment in Building (< 5 storeys)**	**Apartment in Building (≥ 5 storeys)**	**Total Completions**
2006 Census	23,365	17,020	1138
Calculated ratio	0.6	0.4	
2006/7 Completions (calculated)	658	480	
2007	24,023	17,500	

5. In 2007, Brant City and Brantford CA combined to form Brantford CMA. The completions for 2006 include Brantford CA plus Brant City, while the original Census data includes only Brantford CA.
6. Conversions, de-conversions and demolitions were not considered due to incompatibility of data sets.

Commercial/Institutional/Industrial Building Stock
As much as the residential building stock in the Greater Golden Horseshoe is complex in its density and form, the Commercial/Institutional/Industrial (C/I/I) building stock is complex in its distribution and scale. An analysis of the current C/I/I stock in the Greater Golden Horseshoe proved inherently more complex; data sources from both Statistics Canada and Natural Resources Canada were used but were not able to provide a comprehensive enumeration.

Commercial and Institutional Building Energy Use Survey (CIBEUS) 2000
The starting point for our analysis was the above captioned report produced by Natural Resources Canada (NRCan). As part of their initial statistical analysis, the study uses Statistics Canada's Business Register to source sample buildings, and uses several criteria to narrow their sample to suit their purposes. One such criterion is the geographic limitation of the study to CMAs or CAs with populations of 175,000 or greater, which, for our purposes, does not give a comprehensive view of the GGH region. In addition, the data source does not include industrial buildings; a third limitation of this data source is that it does not distinguish between the two building types.

C/I/I Building Permits
Statistics Canada provided this study with Building Permit application numbers for the years 2000-2007, in order to assist us in estimating the completions during this time frame. It is understood that an issued building permit does not necessarily result in a completion nor does it guarantee a "start" within the calendar year of its issue, but it is useful information in terms of generating a rough estimate.

		2000	2001	2002	2003	2004	2005	2006	2007	TOTAL
Toronto	Com	814	1,235	1,056	1,021	735	673	680	795	11,977
	Ind	404	451	443	430	448	400	368	380	
	Inst	207	256	255	280	168	126	172	180	
	C/I/I	1,425	1,942	1,754	1,731	1,351	1,199	1,220	1,355	
Hamilton	Com	73	105	116	87	122	112	90	86	1,566
	Ind	87	69	42	43	51	47	57	61	
	Inst	38	25	52	45	39	41	43	35	
	C/I/I	198	199	210	175	212	200	190	182	
Oshawa	Com	43	46	50	79	63	307	59	45	1,222
	Ind	34	31	28	37	41	33	37	32	
	Inst	50	14	20	31	32	29	55	26	
	C/I/I	127	91	98	147	136	369	151	103	
St. Catharines/ Niagara	Com	128	125	173	107	127	94	107	69	1,750
	Ind	118	105	96	94	78	64	49	55	
	Inst	31	23	20	20	16	12	15	24	
	C/I/I	277	253	289	221	221	170	171	148	
Kitchener	Com	100	70	89	93	102	106	79	67	1,785
	Ind	151	118	125	80	121	96	76	69	
	Inst	59	32	26	23	22	28	26	27	
	C/I/I	310	220	240	196	245	230	181	163	

Table 52. Commercial, industrial and institutional building permits issued 2000-2007, inclusive.

The data were summarized annually across categories, and the commercial and industrial totals were added to the C/I totals from the CIBEUS 2000 report. This estimate was compared to gross statistical data obtained from the Municipal Property Assessment Corporation and indicated reasonable agreement.

CMA/CA	C/I in 1999	C/I/I Building Permits 2000-07	TOTAL C/I/I
Toronto	34,213	11,977	46,190
Oshawa	1,609	1,222	2,831
Hamilton	4,769	1,566	6,335
GTA+H	**40,591**	**14,765**	**55,356**
St. Catharines	3,106	1,750	4,856
Kitchener	3,243	1,785	5,028
Outer Ring	**6,349**	**3,535**	**9,884**
GGH	**46,940**	**18,300**	**65,240**

SOURCES:
- Natural Resources Canada. Commercial and Institutional Building Energy Use Survey 2000 (CIBEUS) - Detailed Statistical Report. P. 492-3.
- Statistics Canada. Building Permits / Permis de bâtir, Publication 64-001-XWF.

Table 53. Estimate of existing commercial/institutional/industrial buildings in the Greater Golden Horseshoe.

NOTES:
1 The December 1999 version of Statistics Canada's Business Register (BR) (more specifically, the location file) was the main source used to build the first-stage sampling frame.
2 Only surveyed Census Metropolitan Areas (CMAs) or Census Agglomerations (CAs) with populations of 175,000 or more.
3 Only Commercial and Institutional Buildings were considered: "*Excluded from the BR were all locations where the main activity was agriculture, forestry, fishing and hunting (NAICSa 11), mining and oil and gas extraction (NAICS 21), utilities (NAICS 22), manufacturing (NAICS 31-32-33), mobile food services (NAICS 72233), private households (NAICS 814), and international and other extraterritorial public administration (NAICS 91911). Locations with no employees, those outside the targeted CMAs and CAs or those where the postal code corresponded with a post office box were also excluded.*" (NRCan, p. 476)
4 The CIBEUS target population includes all buildings with an area of at least 93 square metres (1,000 square feet), of which 50 percent or more is devoted to commercial or institutional activities
5 Building Permit data used does not include demolitions, conversions or deconversions, but may include modifications to existing buildings.

As of the end of 2006 in the GTAH, it has been estimated there are approximately 2,185,850 dwellings: 1,011,713 are single-detached; 781,592 are apartments; and the remaining 364,217 are semi-detached or row houses. It is projected that by 2031, an additional 816,962 dwellings will be constructed and their types will roughly correspond in proportion to the existing housing stock. This means that by 2031, approximately 1 in 4 of the 3,002,812 dwellings are potentially as green as those complying with the Toronto Green Development Standard.

It is estimated there were some 55,356 commercial/institutional/industrial (C/I/I) buildings in the GTAH as of the end of 2006. It is forecast that some 31,874 new C/I/I buildings will be constructed in the period from 2007-2031 assuming the population growth projections are realized. By 2031, C/I/I buildings constructed under the TGDS will represent approximately 1 out of every 3 of the total 87,230 C/I/I buildings.

The diffusion impact of the TGDS will be very high, more so in the non-residential buildings sector, and especially in the commercial market where energy costs affect competitiveness. Existing facilities will be abandoned in favour of newer and higher performing developments causing owners of existing buildings to upgrade or reduce rents to offset higher energy costs. The energy and greenhouse gas reductions potential of existing buildings far exceeds that in new developments, hence it is vital that the Toronto Green Development Standard is extended to include existing building stock.

Water Efficiency and Water Quality

The influence of green development practices on improving the efficiency of water use, and the quality of stormwater runoff does not actually save money per se under the 'user pay' systems that are gradually being introduced across the GTAH. Instead, measures aimed at reducing potable water consumption and effectively managing stormwater avoid future costs associated with less appropriate and effective technologies. This part of the cost-benefit matrix development begins with a look at water efficiency.

Water Efficiency Plan

In 1993, Metro Council adopted a water reduction target of 15% by 2011 to reduce the need for capital expenditures in both water and wastewater. By December 2002, the City of Toronto published its Water Efficiency Plan (WEP) outlining programs and measures to be implemented within a ten-year period to meet consumption demand. The 2011 demand was estimated using population estimates and a "business as usual" water consumption, revealing that peak demand would reach 2,183 million L/day if an efficiency plan were not implemented. The WEP, as laid out in 2002, was estimated to cost $74 million and save an estimated $220 million dollars in expansion fees, due to a reduction in peak demand by 266 ML/day.[119]

WEP COSTS AND BENEFITS	
Current Capacity (2002) (ML/d)	1820
Peak demand 2011 (ML/d)	2183
WEP Peak demand 2011 (ML/d)	1908
Cost to meet 2011 peak if WEP not implemented ($000,000)	220
PV of unit cost to expand water treatment infrastructure ($/L/d)	0.47
PV of unit cost to expand wastewater treatment infrastructure ($/L/d)	0.65
TOTAL AVOIDED COST ($/L/d)	**1.12**
PV represents the current worth of future expenditures that includes inflation and compound interest.	

Table 54. Summary of WEP costs and benefits.

The WEP contained comprehensive programs through incentives for various sectors including Industrial, Commercial and Institutional (ICI), multi-unit residential and the single-family dwelling. At the top of the list was the toilet replacement program, which would require the replacement of over 700,000 toilets with a savings of approximately 100 million L/day. This program, which represents 57% of the $74 million dollar budget, is currently in full swing as a priority within the WEP.[120] The washing machine replacement program is another high priority for the WEP in the single-family and multi-unit residential sectors. The results of a 1999 Pilot Study demonstrated that laundry water use was reduced, on average, by 46% and the cost of heating water for laundry was reduced by 63%, without affecting user satisfaction.

[119] Water Efficiency Plan. City of Toronto, Works & Emergency Services, December 2002. p. 17. However, in Toronto Water's Multi-Year Business Plan (Toronto Water, 2005) the WEP is said to reduce capital budget requirements by $146 million and operating budget by $29 million over 10 years. http://www.toronto.ca/watereff/plan.htm

[120] 2007 Budget Briefing Note - Updating the Water Efficiency Rate. Toronto Water, January 5, 2007, p.1. http://www.toronto.ca/budget2007/pdf/capbn_waterefficiency.pdf

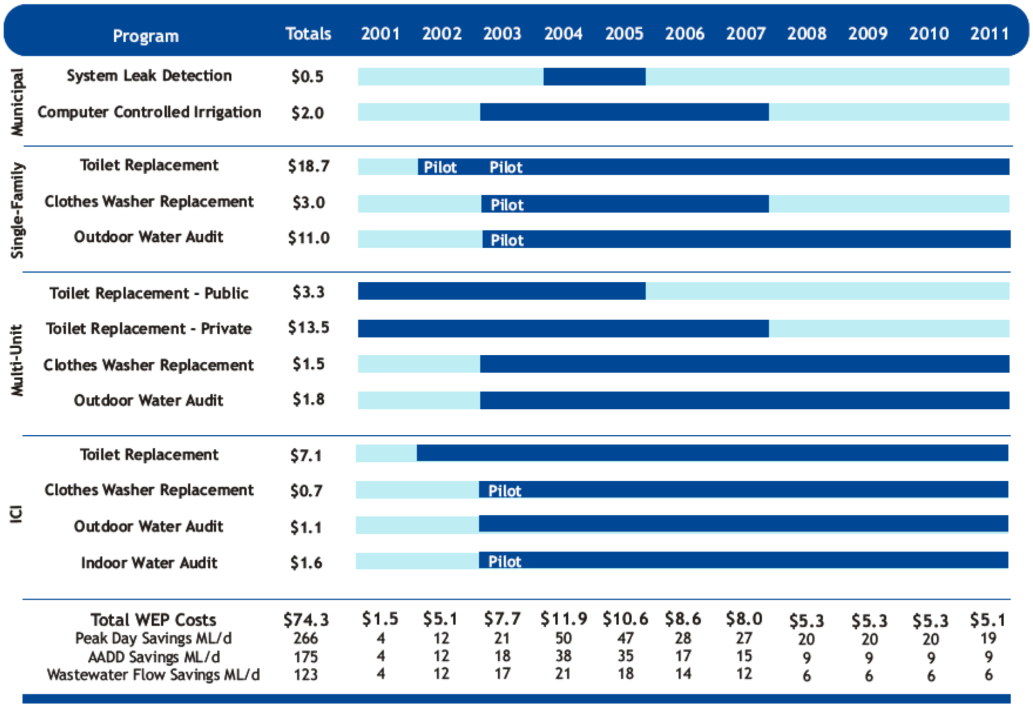


Figure 62. Water Efficiency Plan – Implementation Schedule.
[Source: *Water Efficiency Plan*. City of Toronto, Works & Emergency Services, December 2002, p. 22. http://www.toronto.ca/watereff/plan.htm]

The City has been tracking the success of the WEP, as part of the Toronto Water Annual Reports summarizing annual program uptake and water consumption rates.

Projections

Toronto Water has projected future water demands based on population analysis and developed in association with the City of Toronto Official Plan. The Flashforward population tables, developed in 2002, predict a Toronto population only slightly lower than the predictions in Places to Grow Reference Scenario:

Year	Places to Grow	Flashforward
2001	2,590,000	2,471,355
2011	2,760,000	2,742,345
2021	2,930,000	2,822,569
2031	3,080,000	2,905,426

Table 55. Toronto population forecasts.
[Sources: *Places to Grow - Growth Plan for the Greater Golden Horseshoe.* Ministry of Public Infrastructure Renewal, 2006. Schedule 3. http://www.pir.gov.on.ca/English/aboutpir/publications/PGPENGfullPP.pdf; *Flashforward: Projecting Population and Employment to 2031 in a Mature Urban Area.* Urban Development Services, June 2002. http://www.toronto.ca/torontoplan/flashforward.htm]

Toronto Water indicates that the currently available sustainable supply of water to the City is 1762 ML/day, while current demand is 1728 ML/day. Water demand in 2031 is projected to be 1956 ML/day, and will be met with a capacity of 1963 ML/day, made available through system expansion and agreements in place with the Region of York. This prediction is only marginally higher than predictions for 2011 demand made in the early days of the WEP development (a 2% increase over 2011 prediction, with a 6% population increase).

Water Capital and Operating Costs
The following table summarizes 2007 expenditures by Toronto Water in the area of drinking water treatment and supply:

Budget Line	Water Treatment and Supply
Operating	$110,773,000
Capital	$132,698,000
Total	**$243,471,000**

Table 56. Toronto Water – Operating and Capital Spending in 2007.
[Source: Toronto Water]

Water Rates
As of January 1, 2008, the City of Toronto has moved from a seven block water rate structure to a single rate system with a lower block rate for industrial users on consumption over and above 6,000 m^3.

According to Toronto Water, a rate increase of 9% per year is expected for the next 5 years to accommodate Water Efficiency Plan conservation measures and planning for 2031 demand.

Wastewater Capital and Operating Costs
The following table summarizes 2007 expenditures by Toronto Water in the area of wastewater collection and treatment:

Budget Line	Collection and Wastewater Treatment
Operating	$137,815,000
Capital	$86,368,000
Total	**$224,183,000**

Table 57. Toronto Wastewater - Operating and Capital Spending in 2007.
[Source: Toronto Water]

Avoided Capital Costs

The costs to expand the water and wastewater treatment capacity in the City of Toronto are $520/m3/day and $710/m3/day, respectively, in order to meet the additional demand. The following tables describe various scenarios for the City of Toronto's waterworks and wastewater treatment.

Business As Usual				
	Population	**Capacity (ML/day)**	**Capital Cost for Expansion**	**/100,000 pop. increase**
2006/7	2,503,281	1762		
2031	2,905,426	2045		
Change	402,145	283	$348,034,231	$86,544,463

Table 58. Capital cost of expansion to meet 2031 demand without Water Efficiency Plan implementation.
[Source: Toronto Water]

Toronto Water WEP/TGDS				
	Population	**Capacity (ML/day)**	**Capital Cost for Expansion**	**/100,000 pop. increase**
2006/7	2,503,281	1762		
2031	2,905,426	1963		
Change	402,145	201	$247,137,725	$61,454,879

Table 59. Capital cost of expansion to meet 2031 demand with Water Efficiency Plan implementation, consistent with TGDS objectives.
[Source: Toronto Water]

25% Potential Reduction beyond WEP/TGDS						
	Population	**Capacity (ML/day)**	**L/person/ day**	**Capacity (ML/day)**	**Capital Cost for Expansion**	**/100,000 pop. increase**
2006/7	2,503,281	1762	704			
2031	2,905,426		528	1,534		
Change	402,145			(228)	$0.00	$0.00
25% Potential Reduction beyond WEP/TGDS						
	Population	**Capacity (ML/day)**	**L/person/ day**	**Capacity (ML/day)**	**Capital Cost for Expansion**	**/100,000 pop. increase**
2006/7	2,503,281	1762	704			
2031	2,905,426		352	1,023		
Change	402,145			(739)	$0.00	$0.00

NOTES:
Business As Usual
- 2007 capacity as provided by Toronto Water.
Toronto Water WEP/TGDS
-2007 and 2031 capacity as provided by Toronto water
Potential - 25% reduction
Potential - 50% reduction
SOURCES:
-population from City of Toronto Fastforward (as presented by Toronto Water)
-capacities for: present day, 2031 Toronto Water WEP/TGDS from Toronto Water

Table 60. Capital cost of expansion can be potentially avoided by higher water efficiency targets.
[Source: Toronto Water]

Toronto Water Facts

- The City of Toronto water reservoirs contain between 2 and 2-1/2 days of water supply based on normal consumption rates.
- There are no emergency generators big enough to operate the water treatment plants in the event of an electricity system failure.
- It takes 9 pumping stages and 6 days for water from a treatment plant in Toronto to reach the top reservoir of York Region.
- Total water consumption in 2006: 514,000 megalitres (ML).
- Average daily water demand: 1,408 ML/day - more than enough to fill the Roger's Centre (former Skydome).
- Average household use in 2006: 315 cubic metres/year = $455/year for water and wastewater.
- Residential water usage accounts for approximately 51% of water used in City.
- Toilets are the #1 indoor water users - they account for 28% of total indoor water use (100 litres of water/day).
- 438 billion litres of wastewater (sewage) is treated each year. Water rates increased by 9% in 2003, 6% in 2004 and 2005, and 9% in 2006 and 2007.
- The 2007 increase resulted in an average annual increase of $40 for the average household (family of four).
- An average water bill for metered households was $429 in 2006, now $469 in 2007.
- Despite recent increases, Toronto still has one of the lowest water rates in the GTA.

[Sources: Various City of Toronto reports, bulletins and data.]

Avoided Operating Costs

Table 61 summarizes the estimated annual operating costs in 2007 dollars for the various water efficiency scenarios. Assuming that ultra low flow plumbing fixtures, high water efficiency appliances and rainwater harvesting for irrigation purposes become widespread practices in Toronto under an evolving Toronto Green Development Standard, it is likely that a further 25% reduction in water consumption can be realized beyond targets called for under the Water Efficiency Plan.

	2031		
2007	**Toronto Water WEP/TGDS**	**25% reduction**	**50% reduction**
$248,588,000	$276,946,000	$216,392,000	$144,261,000

Table 61. Annual operating costs based on various levels of water efficiency.
[Estimates extrapolated from Toronto Water data.]

Using the data from the preceding tables for water, operating cost savings and avoided capital costs could be estimated per 100,000 population increase. This estimate could then be applied to the Greater Toronto Area and Hamilton population forecast to determine the total savings and avoided costs expressed as a net present value in 2007. The results are summarized in Table 61 and it is important to note that the costs associated with these conservation measures have already been included in the green development capital cost premium that was considered under the preceding section on energy conservation.

Avoided capital cost per 100,000 population	$61,454,879
Annual operating cost savings per 100,000 population	$1,040,789
Population growth 2007-2031	2,560,000
Total Avoided Costs 2007-2031	$1,573,244,911
Operating Cost Savings 2007-2031	$346,374,579
Total Avoided Costs and Operating Savings	**$1,919,619,490**

Table 62. Assessment of benefits associated with water conservation potential under the Toronto Green Development Standard.
[Note: It is assumed the 25% reduction in water consumption is phased in at 1% per year over the 25-year period.)

Water Quality

Improvements to water quality are largely achieved through appropriate stormwater management practices. In 2007 the City of Toronto spent $21.6 million on capital projects and purchases related to stormwater management.

Category	Capital Cost ($M)
Source control	4.2
Stream Restoration	4.4
WWFMMP Implementation	1.9
Conveyance	6.4
End of Pipe	0.9
Basement Flooding	3.8
TOTAL	**21.6**

Table 63. Stormwater capital costs for the City of Toronto in 2007.
[Source: Toronto Water]

These capital expenditures did not include the addition of any new stormwater infrastructure. The major focus of the spending was the rehabilitation of existing outfalls and storm sewers, replacement of storm sewers. A significant sum was also spent on downspout disconnection programs, while only $1.9 million was spent on the implementation of projects related to the Wet Weather Flow Management Master Plan.

Wet Weather Flow Management Master Plan

There is no straightforward method of predicting how population growth and development will affect the economics of stormwater management in the City of Toronto. Suffice it to say that an increase in impervious surface area will increase volume of stormwater and put greater strain on an already overtaxed stormwater management system. For this reason site stormwater control in accordance with the TGDS and the Wet Weather Flow Management Guidelines are critical.

Public Sector Funding of WWFMMP

For comprehensive implementation of the plan, the City of Toronto projects capital and operating costs over the 25-year timeframe in the order of $1.1 billion and $251 million, respectively.

5 year block	Capital Cost per 5 Year Block	Operating Cost per 5 Year Block	Total Cost per 5 Year Block
2003-2007	$179,672,000	$23,713,000	$203,385,000
2008-2012	$304,407,000	$29,272,000	$333,679,000
2013-2017	$268,924,000	$35,704,000	$304,628,000
2018-2022	$209,043,000	$76,429,000	$285,472,000
2023-2027	$166,638,000	$85,752,000	$252,389,000
Total	**$1,128,683,000**	**$250,870,000**	**$1,379,553,000**
NOTES: - from Toronto Water - converted from 2003 dollars to 2007 dollars using annual Core CPI data from the Bank of Canada.			

Table 64. Public sector funding of the WWFMMP.
[Source: Toronto Water]

COMPONENT OF PLAN	CAPITAL COST ($2007 million)
PUBLIC EDUCATION - city wide over 25 years • focused on increasing public awareness	32
SOURCE CONTROLS - city wide over 25 years • existing ~ 10-15% participation rate target of • 40% participation rate is proposed	121
MUNICIPAL OPERATIONS - city wide over 25 years • search & eliminate Dry Weather discharges • enhanced street sweeping and catchbasin cleaning • monitoring of Plan implementation and effectiveness	9
BASEMENT FLOODING – emphasis in first 5 years • focused on cluster areas previously identified • sewer system upgrading & "home isolation" program	59
CONVEYANCE CONTROLS - city wide over 25 years • protect existing ditch network • exfiltration systems ("leaky" storm sewers)	80
SHORELINE MANAGEMENT - implemented in first 10 years • Humber River and Etobicoke Creek deflector structures • Restoration of Highland Creek and Rouge Park Marshes	45
STREAM RESTORATION - emphasis in first 15 years • focus on protecting City's infrastructure • restore aquatic stream habitats • 104 km of stream restoration proposed	141
END-OF-PIPE CONTROLS- implemented over 25 years Green End-of-Pipe: Stormwater Ponds, Constructed Wetlands • opportunistic basis where sufficient open space available • 180 facilities proposed	113
Underground Storage: space limited considerations • necessary to address combined sewer overflows • 16 CSO facilities proposed • 50 stormwater facilities proposed • 4 CSO treatment facilities proposed	529
Total Capital Cost	**1,128**
Operation & Maintenance Cost (associated with the new stormwater control measure)	**251**
NOTES: - from Toronto Water - converted from 2003 dollars to 2007 dollars using annual Core CPI data from the Bank of Canada.	

Table 65. Component costs of the WWFMMP.
[Source: *Wet Weather Flow Management Master Plan Overview and 25 Year Implementation Plan*, City of Toronto, July 2003. p. 20. http://www.toronto.ca/involved/projects/archived/wwfmmp_archive/pdf/wwfmmp_25yr_overview_report.pdf]

The End-of-Pipe Controls section indicates that $113 million will be spent on Green controls while $529 million will be spent on the construction of new underground stormwater storage capacity. According to the rule of thumb used by the City with respect to the Cash-in-Lieu option (see section "*Application of the WWFM Guidelines to New Development*") this represents approximately 529 million litres of stormwater storage.

Private Sector Funding

Investment in the WWFMP will not only come from public funding - private property owners will also contribute financially to the implementation of the plan. Expenditures as estimated in terms of 25-year and 100-year schemes of the WWFMP and are presented by study areas in the following table:

Study Areas	25-year plan	100-year plan
Combined Sewer Service Area	Not identified	Not identified
Etobicoke and Mimico Creek	$54,407,000	Not identified
Humber River	$175,612,000	$472,968,000
Don River	$218,707,000	$506,366,000
Highland Creek and Rouge River	$238,100,000	$579,628,000
TOTAL	**$686,827,000**	**$1,558,962,000**

NOTES:
- from Toronto Water
- converted from 2003 dollars to 2007 dollars using annual Core CPI data from the Bank of Canada.

Table 66. Private Sector Funding of the WWFMMP.
[Source: Toronto Water]

This funding includes what the property owners would spend on aesthetics or other measures and not the cost of meeting the WWFM Guidelines for new development.[121]

Application of the WWFM Guidelines to New Development

Implementation of the WWFMP requires that applicable new developments meet the criteria set out in the guidelines, potentially requiring additional investment in source control for stormwater. For example, a high-density residential development might opt to meet the requirements through the installation of a rainwater harvesting system, rooftop garden, vegetated drainage swale, and disinfection system at a total capital cost in the range of approximately $550,000 to $750,000.[122]

An alternative scenario applies to sites whose conditions might not allow for the implementation of source control measures. This approach would allow these developers to make a cash-in-lieu payment to contribute to the cost of managing their stormwater "downstream". This payment would be based on the level of stormwater quality control for a 20 mm daily rainfall (covering all storms with 24-hour volumes of 20 mm or less), and a capital cost of $1,000/m^3$ – the equivalent of the cost of underground storage in concrete tanks.[123]

[121] Toronto Water.

[122] Sample Application of the WWFM Guidelines. City of Toronto. October 19, 2007. http://www.toronto.ca/water/protecting_quality/wwfmmp_guidelines/pdf/sample_application_of_the_wwfm_guidelines.pdf

[123] Including construction cost + 35% allowance for engineering, contingency and GST, but excluding land costs based on the WWFMP Study. *Wet Weather Flow Management Guidelines.* City of Toronto. November 2006, p. 29. http://www.toronto.ca/water/protecting_quality/wwfmmp/pdf/wwfm_guidelines_2006-11.pdf

Avoided Costs

There has not been an opportunity by the City of Toronto to forecast avoided costs associated with the long term evolution of the WWFMMP. Anticipated costs for expanding the stormwater management system to accommodate new growth are indicated in Table 67.

WWFMMP/TGDS			
Year	**Population**	**Capital Cost for Expansion of Stormwater Capacity**	**Capital Cost / 100,000 pop. increase**
2006/7	2,503,281	$0	
2031	2,905,426	$529,000,000	
Change	402,145	$529,000,000	$131,544,592

Table 67. Forecast stormwater system capital expansion costs.
[Source: Toronto Water]

It is assumed that moving toward landscape infrastructure approaches to stormwater management will practically eliminate these expansion costs. Assuming the forecast population growth in the GTAH up to 2031, and similar expansion costs across the various municipalities, the landscape infrastructure measures applied to satisfy TGDS requirements represent a $3,314,923,722 avoided cost. It should be noted that the landscape infrastructure costs are considered cost neutral compared to conventional stormwater management technologies, hence there are no costs, only benefits due to the avoided costs.

Solid Waste

The discussion on solid waste in the preceding section of this report on urban site technologies indicates that the City of Toronto is moving toward a user-pay system. Diversion is the key strategy being employed to extend the life of landfills and both private and corporate citizens are encouraged to recycle and compost, thereby minimizing the volume of solid waste sent for landfill. However, in the event households and businesses exceed their quota, they will pay a surcharge for the additional solid waste. The only avoided costs come from voluntary restraint, although there is much potential for the rationalization of consumer packaging regulations.

Savings or revenues are mainly through energy production. The biogas produced from compost (site separated organics) is capable of producing renewable energy and at some point in the future, additional energy generation may come in the form of ‘clean’ waste-to-energy systems, such as those employed in Europe. This could enable solid waste management to become a full cost recovery municipal service, however, there remains a great deal of controversy over incineration.

Waste management is dealt with under the Toronto Green Development Standard by requiring proper recycling of materials during construction, and the provision of appropriate waste handling and storage facilities in new developments. It does not significantly require more than is currently being advocated under the Target 70 initiative. Given these considerations, the cost-benefit analysis of solid waste as it relates to the Toronto Green Development Standard is questionable. For the purposes of this study, the costs and benefits of solid waste management requirements in the TGDS are assumed to be equal until such time as there is better information available to guide a meaningful assessment.

Air Quality

The Toronto Green Development Standard approaches air quality holistically and considers means of reducing outdoor and indoor sources of air pollutants. The planning of new developments near public transportation, and designing communities that encourage pedestrian and cycling transportation modes are intended to reduce automotive emissions. Minimizing the importing of materials from distant locations and discouraging construction activities that produce contaminants and particulates have the same intended effect on outdoor air quality. It is problematic to properly assess these requirements from a cost-benefit perspective simply because it is difficult to estimate their impact, given that these are dependent on the individual behaviour of a large and diverse industry.

The urban heat island effects at the roof and ground levels are also intended to improve outdoor air quality. The cost-benefit relationship for both of these requirements has been addressed under stormwater management, where the landscape infrastructure technologies, including green roofs, were assessed as being highly cost effective.

Indoor air quality costs and benefits of the TGDS requirements are covered under energy conservation in the case of heat recovery ventilators. For low emission materials, these are not seen as representing a significant cost difference as more manufacturers move toward creating healthier materials. Regardless, it is not possible to estimate the benefits associated with providing improved indoor air quality.

Energy conservation results in fewer emissions from gas furnaces, boilers and fossil-fuelled electricity generation plants. There are several bodies of research that relate air pollution to the cost of health. A relatively recent study on the subject was published in Ontario in the year 2000 by the Ontario Medical Association.[124] Its one drawback is that it did not distinguish between building and automobile contributions to air pollution. More recently in 2007, Toronto Public Health released a report that assessed the traffic contributions to health burdens.[125]

Working with both of these reports, it was possible to estimate the non-traffic related air pollution burdens. For the purposes of this study, it was assumed the contribution of energy conservation to improving air quality would be similar to what was ascribed to Ontario's voluntary Anti-Smog Action Plan in the year 2000 OMA study, specifically that Ontario could avoid $1.2 billion in health care system burdens annually. These avoided costs were assumed to be attained under the TGDS energy efficiency requirements by 2031. Based on the more recent study, approximately 20.8% of total air pollution health burdens are attributable to traffic. The Greater Toronto Area and Hamilton currently accounts for 49.8% of Ontario's total population. Using these previous data, the net present value of avoided health burdens was assessed at $10,178,699,093 for the 2007-2031 study period.

There is some concern that building development may not account for almost 80% of air pollution as assumed in this assessment. However, a large amount of air pollution is caused by manufacturing and much of this is geared towards producing building products and materials. Further, the replacement of coal-fired electrical generating plants with cleaner and renewable energy sources may displace more pollution than the Anti-Smog Action Plan. It is important to note that in order to partially account for this uncertainty, the year 2000 health costs were not adjusted to 2007 values, hence the present value of avoided health burdens has been somewhat conservatively estimated.

[124] *The Illness Costs of Air Pollution in Ontario: A Summary of Finding*. Ontario Medical Association, June 2000. http://www.oma.org/phealth/icap.htm

[125] *Air Pollution Burden of Illness from Traffic in Toronto*. Toronto Public Health, November 2007. http://www.toronto.ca/health/hphe/air_pollution_burden.htm

Ecology

Requirements for ecology under the Toronto Green Development Standard are mostly associated with protection of the urban forest and wildlife habitats and the reduction of bird kills and light pollution. Of all the TGDS requirements, these have proven to be most difficult to assess from a cost-benefit perspective because there is so little economic analysis found in the literature that specifically relates to each requirement.

However, a considerable amount of research has been conducted and published on the value of ecological services and assets. Some of the findings from Professor Pierre Bélanger's compendium report on urban stormwater economics (see Appendix D) have been excerpted to indicate an order of economic magnitude for ecological valuation purposes.

Table 68. Average Annual Global Value of Ecological Services*

Biome	*Total Value / Hectare / Year*
Marine (Oceans, Estuaries, Reefs)	$577,000,000,000
Forests	$969,000,000,000
Grass/Rangelands	$232,000,000,000
Wetlands	$14,785,000,000,000
Lakes/Rivers	$8,498,000,000,000
Cropland	$92,000,000,000

*Values are in 1994 US dollars. The values do not incorporate the 'infrastructure' value of ecosystems, leading to an underestimation of the total value according to Costanza *et al.* "The value of the world's ecosystem services and natural capital" *Nature* 387 (1997): 253-260.

Table 69. Breakdown of the Economic Values of a Single Mature Tree in the Urban Forest*

Benefit	*Rate*	*% Reduction*	*Economic Value*
Storm Water & Soil Erosion Control	1300 litres/rainfall	12-17%	$75.00
Air Pollution Control	50-100kg/year	-	$50.00
Energy Savings (Air Conditioning)	-	8-12%	$73.00
Wildlife Shelter	-	-	$75.00
Total Value in 1985 Dollars	-	-	$273.00
Total Value for 50 years**	**-**	**-**	**$57,151.00**

*According to a 1985 study by the American Forestry Association (now called American Forests). Primary source unknown, cited from the City of Regina Department of Urban Forestry: www.regina.ca/trees/PDFs/Benefits.pdf
** Total value compounded at 5 per cent interest for 50 years.

Table 70. Avoided Stormwater-Construction Costs attributed to Urban Forests*

Urban Area	*Savings from Urban Forests in one-time Stormwater construction costs***	*Total Size of Study Area*	*Percentage Forest Cover****
Houston, Texas	$1.33 billion	160,000 ha (395,000 acres)	30.0%
Atlanta, Georgia	$2.36 billion	314,000 ha (775,000 acres)	29%
Vancouver, Washington/ Portland-Eugene, Oregon	$20.2 billion	2.83 million ha (7 million acres)	25%
Washington D.C. Metro Area	$440 million	164,700 ha (43,000 acres)	21%
Delaware Valley region/Philadelphia	$5.9 billion	0.97 million ha (2.4 million acres)	20-29%
Mecklenburg County, North Carolina	$1.87 billion	142,000 ha (351,000 acres)	53%
Fayetteville, Arkansas	$92 million	12,000 ha (29,000 acres)	27%
Canton-Akron, Ohio	$414 million	395,000 ha (975,000 acres)	20.5%
Detroit, Michigan	$382 million	36,000 ha (88,855 acres)	31%
Chesapeake Bay Region, Charlottesville-Harrisburg,	$1.08 billion	0.61 million ha (1.5 million acres)	21%-26%
Buffalo-Lackawanna, New York	$35.5 million	13,200 ha (32,600 sq. miles)	12%
Greater Toronto Area	*$3.5 billion*	*590,363 ha (1,458,000 acres)*	*20%*
Greater Toronto Area (Projection)	*$7 billion*** **	*590,363 ha (1,458,000 acres)*	*40%*

* As measured by the American Forest's CITY Green Model (2000-2006), reproduced in ECONorthwest, "The Economics of Low Impact Development: A Literature Review" (November 2007): p.24.
** Amounts are based on an average range of $2.00 to $5.00 per cubic foot for construction costs to build equivalent retention facilities.
*** Total Number of Trees & Percentage of Total Land Area are estimates compiled from data and statistics from American Forests' Urban Ecosystem Analysis: www.americanforests.org/resources/rea/
**** Projected values for Toronto assume that 1 hectare of urban forest can store a minimum of 350 cubic meters of water (5000 cu.ft./acre) and that the equivalent cost of stormwater construction is $85.00 per cubic meter ($2.50/cu.ft.). Considered as conservative estimates, the values are based on an average of storage volume capacity and equivalent stormwater construction costs for cities in the Great Lakes Region and across North America, according to the American Forests' Urban Ecosystem Analysis: www.americanforests.org/resources/rea/

Table 71. Summary of Freshwater Wetland Services & Values

Study	*Services*	*Reported Values in Acres/ Year (in $US, 2006 value)*
Woodword and Wiu (values are not additive since in any one example, studies primarily providing one service type also provide other services)	Flood	$595
	Quality	$632
	Quantity	$192
	Recreational fishing	$541
	Commercial fishing	$1,179
	Bird Hunting	$106
	Bird Watching	$1,836
	Amenity	$5
	Habitat	$464
	Storm	$359
Kazmierczak	Habitat and species protection	$287
Costanza et al	Habitat/Refugia	$235
	Recreation	$263
	Total ecosystem services	$10,482
Arreola	Preserve/restore total services	$956
Breunig	Total ecosystem services	$17,307
Olewiler	Total ecosystem services (Low)	$4,217
	Total ecosystem services (High)	$17,712

This table is by no means exhaustive, nor does it present all the benefits of wetlands. For a greater discussion, see International Lake Ontario & St. Lawrence River Study, *Valuating Wetland Benefits compared with Economic Benefits and Losses* (April 27, 2006), http://www.losl.org/reports/20060427_wetlandvalue_e.html#s4

The data indicate that our ecology is practically priceless, certainly invaluable. But it is not clear if the value it provides is necessarily enhanced by the Toronto Green Development Standard. Rather, it may that the TGDS is simply one among a large number of initiatives being taken across the GTAH to help preserve ecological assets and services.

Based on the available data, there is no direct correlation between ecological costs and benefits in relation to the TGDS. Therefore, it has been decided that for the purposes of this study, requirements for ecology under the Toronto Green Development Standard would be assessed under intangible costs and benefits.

Synopsis of Monetized Costs and Benefits

The costs and benefits associated with adopting the Toronto Green Development Standard over the business as usual model are summarized in Table 72.

Table 72. Toronto Green Development Standard vs Business As Usual Cost-Benefit Matrix

All values expressed in 2007 dollars.

	Costs	Benefits (Savings)		
	2007-2031	**2007-2031**	**2032-2056**	**2057-2081**
Green Development versus BAU (4.5% premium)	$10,420,050,925			
Energy Conservation				
Current Energy Price Escalation Scenario		$11,045,945,779	$19,278,767,891	$49,179,925,202
High Energy Price Escalation Scenario		$14,765,176,440	$29,962,914,995	$114,073,074,237
GHG Emission Reductions @ $30/tonne		$437,193,462	$1,143,314,245	$1,143,314,245
Avoided Electrical System Costs	($990,614,337)			
Stormwater				
Avoided Costs - Landscape Infrastructure	($3,314,923,722)			
Water and Wastewater				
Avoided Expansion Costs and Operating Savings	($1,573,244,911)	$346,374,579		
Air Quality				
Avoided Costs - Buildings Related	($10,178,699,093)		($10,178,699,093)	($10,178,699,093)
Solid Waste	Indeterminate.			
Ecology	Considered as a non-monetized intangible.			
Total - Current Energy Price Escalation Scenario	($5,637,431,138)	$11,829,513,820	$30,600,781,229	$60,501,938,539
Total - High Energy Price Escalation Scenario	($5,637,431,138)	$15,548,744,481	$41,284,928,333	$125,395,087,574
Net - Current Energy Price Escalation Scenario		$17,466,944,958	$36,238,212,366	$66,139,369,677
Netl - High Energy Price Escalation Scenario		$21,186,175,619	$46,922,359,470	$131,032,518,712
RE&EE Industry Revenues		$95,000,000,000	?	?
Employment		860,000	?	?

The net present value of benefits associated with the Toronto Green Development Standard total $17.46 billion under the current energy price escalation scenario, and $21.19 billion under the high scenario for the period 2007-2031. This grows to $36.24 billion and $46.92 billion respectively, under the two scenarios for the period 2032-2056. By the end of the useful life of the building development during 2007-2031, the net benefits realized range from $66.14 billion under the current energy price escalation scenario, and $131.03 billion under the high scenario for the period 2057-2081. These amounts represent the net present values of future burdens placed on succeeding generations if the business as usual development model persists for the next 25 years. Moving toward the Toronto Green Development Standard also has the benefit of generating some $95 billion in annual revenues from the renewable energy and energy efficiency industry by 2031. Assuming inaccuracies in the assumptions and data employed to generate this assessment, the margin of benefits tends to strongly outweigh any reasonable margin of error.

Beyond the development industry, municipal governments also have a vested interest in green development. According to the Region of Halton, its population is projected to grow by some 341,000 people above the 2006 census population of 439,000 to reach 780,000 people by 2031 under the Places to Grow legislation. The regional municipality of Halton has conducted estimates of the corresponding infrastructure investments needed to accommodate this growth:

"*Accommodating this growth will require over $8.6 billion in infrastructure including:*

- *1100 hospital beds*
- *50 new elementary schools and 14 new secondary schools*
- *25 community centres, 8 libraries and 1650 acres of parkland development*
- *22 fire halls, 4 ambulance stations and 6 police stations*
- *2000 lane kms of major municipal roadways plus expansions to highways, bridges, interchanges*
- *11 local transit facilities and 175 buses*
- *Additional police and court infrastructure*
- *Expansion of the inter-regional transit capacity including GO Transit*
- *Expansion of electrical power facilities*
- *Landfill/waste disposal capacity*."

[Source: *Fairness for Halton*. http://www.halton.ca/Council/fairness/default.htm]

Based on this projection, it is estimated that new infrastructure accompanying planned growth in the GTAH will cost approximately $25 million per thousand increase in population. From 2007 to 2031, this translates into provincial and municipal expenditures totaling $64.5 billion (2007 dollars) under the business-as-usual scenario. Some portion of this cost may be avoided by municipalities taking a leadership role in advancing the best green development practices for their own projects. It is also important to recognize that the impact of costs associated with infrastructure renewal during this period can be lessened for taxpayers by advocating standards that encourage conservation of resources and hence, household expenditures on energy and water. It may be concluded that green development is a cost effective approach to achieving a sustainable future that poses no real economic hardships on any of the stakeholders.

Intangible Costs and Benefits

As noted in the beginning of this section, intangible costs and benefits have not been, and may well never be, fully monetized. This does not make them any less important. In preparing the monetized costs and benefits assesment, a number of intangibles were identified and their costs and benefits have been summarized in Table 73.

Table 73. Summary of intangible costs and benefits associated with the Toronto Green Development Standard.

Intangible	Costs	Benefits
Healthy Urban Forest	No change in cost of urban forestry management.	Aesthetics, shade, air quality, carbon sequestration and stormwater management.
Preservation of Wildlife Habitat	Sufficient brownfields and infill sites available to accommodate new development – no lost development opportunity costs.	Biodiversity and a healthy ecological system.
Reduced Bird Kills	Bird-friendly development guidelines pose no additional costs.	Wildlife preservation and improved balance of nature among native species.
Reduced Urban Heat Island Effect	Green roofs and landscape costs covered under stormwater management measures.	Improved thermal comfort and air quality.
Reduced Light Pollution	Additional costs recovered through energy savings.	Safer and less intrusive outdoor environment.
Reduced Landfill Groundwater Contamination	No additional cost under TGDS.	Improved groundwater quality.
Improved Indoor Air Quality	Heat recovery ventilation system pays for itself in energy savings.	Improved health and well being.
Improved Outdoor Air Quality	Avoided health costs pay for reduced levels of air pollution.	Improved health and well being. Reduced weathering costs for exposed materials.
RE&EE Employment	Jobs created in response to cost effective energy conservation and generation opportunities.	Secure employment for workers displaced in unsustainable industry sectors.
Green Economy	Cost effective based on menetized costs and benefits.	Sustainable economy based on cultivation and conservation.

It is difficult to imagine a sustainable future that does not consider the intangible values associated with quality of life. Clean air and water, conservation of resources, preservation of wildlife biodiversity and habitats are among the numerous benefits made possible by taking the green development path. Affordable housing and secure employment that cannot be outsourced is of vital importance to social well being. The benefits of green development cannot be realized without understanding another necessary dimension of the transition to a more sustainable world – the key drivers that encourage each of the stakeholders to participate in their common future.

Sustainability Drivers and Green Development

Sustainability is largely an ecological concept and as such is premised on some form of symbiosis. In the case of green development, a commonly encountered question during the study was, "If we discover that green development is cost effective, how can we mobilize the transition to this new way of building new communities?" The problem, as the evidence strongly indicates, is not that the benefits of green development do not outweigh the costs – indeed the green development path is less costly up front and in the long run. Rather, how can this transition promote symbiotic relationships among all the stakeholders that reinforce green development?

The study team examined a number of different models, but eventually settled on the notion of 'quid pro quo' or more commonly, tit for tat as a powerful integrating concept for the realization of the cost-benefit matrix forecasts. The idea was borrowed from the work of Anatol Rapoport:

Anatol Rapoport (May 22, 1911 - January 20, 2007) was a professor of mathematics and psychology at the University of Toronto from 1970 - 1979. In addition to a number of prestigious awards and appointments, he gained fame for winning a computer tournament in the 1980s, based on Robert Axelrod's The Evolution of Cooperation. This sought to understand how cooperation could emerge through evolution. Rapoport's entry,Tit-For-Tat used only four lines of code. The program opens by cooperating with its opponent. It then plays exactly as the other side had played in the previous game. If the other side had defected, the program also defects; but only for one game. If the other side cooperates, the other side continues to cooperate. According to Peace Magazine author/editor Metta Spencer, the program "punished the other player for selfish behaviour and rewarded her for cooperative behaviour - but the punishment lasted only as long as the selfish behaviour lasted. This proved to be an exceptionally effective sanction, quickly showing the other side the advantages of cooperating. It also set moral philosophers to proposing this as a workable principle to use in real life interactions." In describing its virtues, Axelrod says: "What accounts for TIT-FOR-TAT's robust success is its combination of being nice, retaliatory, forgiving and clear. Its niceness prevents it from getting into unnecessary trouble. Its retaliation discourages the other side from persisting whenever defection is tried. Its forgiveness helps restore mutual co-operation. And its clarity makes it intelligible to the other player, thereby eliciting long-term cooperation."
[Sources: http://www.science.ca/scientists/scientistprofile.php?pID=211 http://en.wikipedia.org/wiki/Anatol_Rapoport http://jasss.soc.surrey.ac.uk/1/1/review1.html]

Unlike the original TIT-FOR-TAT algorithm, the sustainability drivers considered in this study involve, essentially, six key stakeholders in the green development game: Consumers; Developers; Utilities (energy, water, etc.); Government; Financial (Banks and Insurance); and implicitly, Society / Environment / Economy. Note that the sum of the interactions between the 5 explicit stakeholders implicitly impacts the social, environmental and economic dimensions – collectively, our common future.

On the pages which follow, Figures 63 to 67 depict a series of sustainability driver relationships between the various stakeholders. These should be viewed as a departure point for a systematic assessment of the various policies, economic and environmental instruments needed to elicit appropriate behaviour that is also rewarding to each stakeholder. The linkages that are proposed do not necessarily exist or may need to be reinforced. The simple concept being advanced is that: *Appropriate behaviour should prove at least as profitable as inappropriate behaviour*. Otherwise, the indications point to a need for changing the underlying economics.

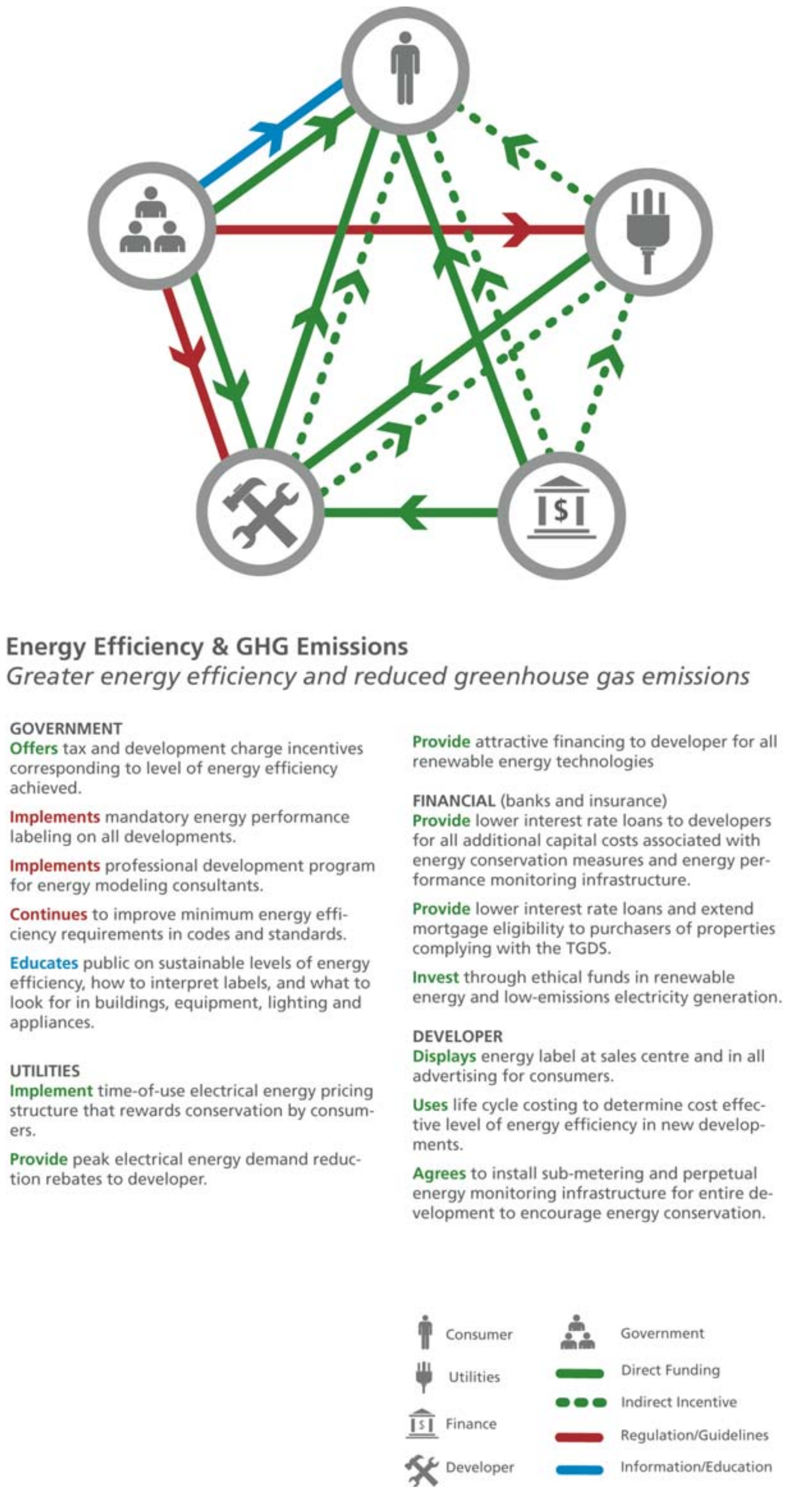
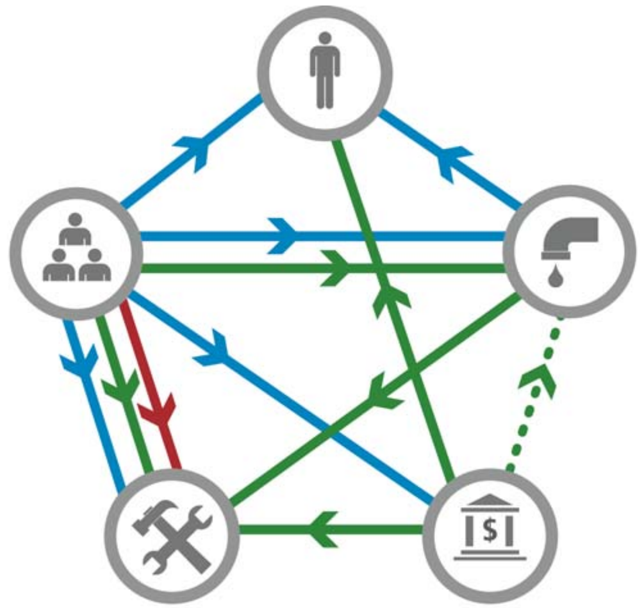


Figure 63. Improvements to energy efficiency and greenhouse gas emission reductions are related to a coordinated ensemble of public education and incentives. Standards act as a ratchet to prevent regressive behaviour.



Water Quality, Efficiency & UHI Effects

GOVERNMENT
Invests in municipal infrastructure and programs that deal with contaminants at the source instead of end-of-pipe solutions (e.g., eliminating combined sewers instead of using online storage systems).

Provides development charge rebates and/or tax credits for projects with net zero impact on water quality/efficiency.

Develops water quality/efficiency management plan and development guidelines to protect water resources.

Monitors water quality and efficiency, provides all stakeholders with "live" feedback (e.g., Internet, The Weather Network, etc.).

UTILITIES
Provide rebates to developer for design of water quality/efficiency management technologies with priority on green roofs and permeable parking lots.

Educate public about products and behaviours that compromise water quality and efficiency.

FINANCIAL (banks and insurance)
Provide lower interest rate loans to developers for all additional capital costs associated with water quality/efficiency management.

Provide lower interest rate loans, insurance premiums and extend mortgage eligibility to purchasers of properties complying with the TGDS.

Invest through ethical funds in water quality and conservation technologies.

DEVELOPER
Agrees to implement appropriate measures for stormwater management and water conservation in exchange for incentives.

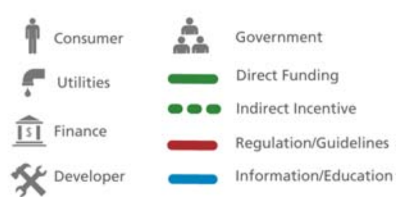
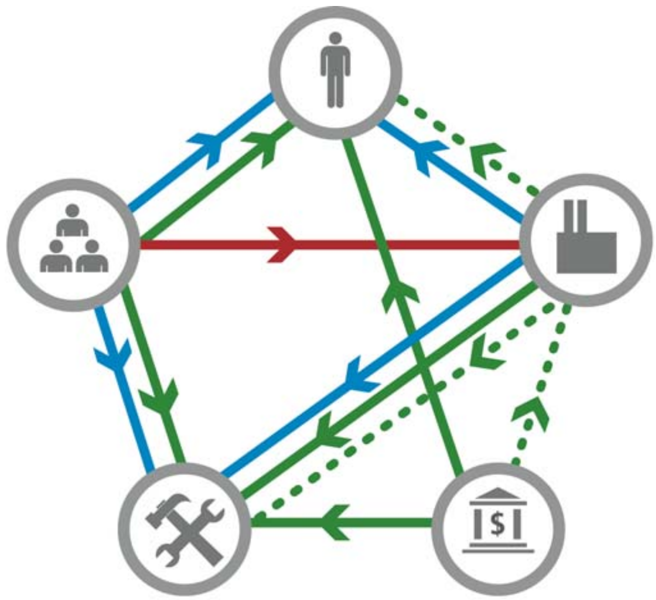


Figure 64. The management of water quality and efficiency is linked to reducing urban heat island effects through strong advocacy for green roof technology.



Air Quality
Better air quality

GOVERNMENT

Monitors air quality, tracks respiratory disease and associated health costs and provides all stakeholders with reliable feedback on impacts of air quality.

Directs health care system savings toward public transportation and bicycle networks.

Reduces development charges for projects situated near public transportation.

Provides tax credit for projects having bicycle storage, change/shower facilities.

Establishes emission targets for automobiles and power plants.

Educates public about benefits of public transit, cycling and walking and offers tax credits for transit/taxi fares and bicycle maintenance/ repairs.

Educates developers about advantages of providing adequate bicycle parking and access to public transit.

UTILITIES

Implement programs for installing, operating and maintaining combined heat and power plants at no initial cost to developer.

Shape time-of-use rate structures to capitalize renewable energy and conservation programs.

Boycott all emission-intensive sources of electrical energy.

Create feedback loops with media links (e.g., energy dashboard on The Weather Network showing peak demand, emissions and air quality).

FINANCIAL (banks and insurance)

Provide lower interest rate loans to developers for all additional capital costs associated with air quality improvements and energy monitoring infrastructure.

Provide lower interest rate loans and extend mortgage eligibility to purchasers of properties complying with the TGDS.

Invests through ethical funds in renewable energy and low-emissions electricity generation.

DEVELOPER

Agrees to implement measures aimed at improving air quality in exchange for incentives.

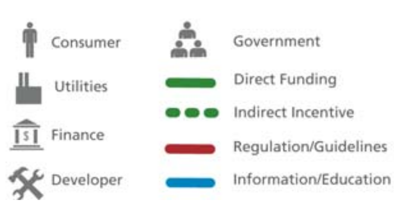
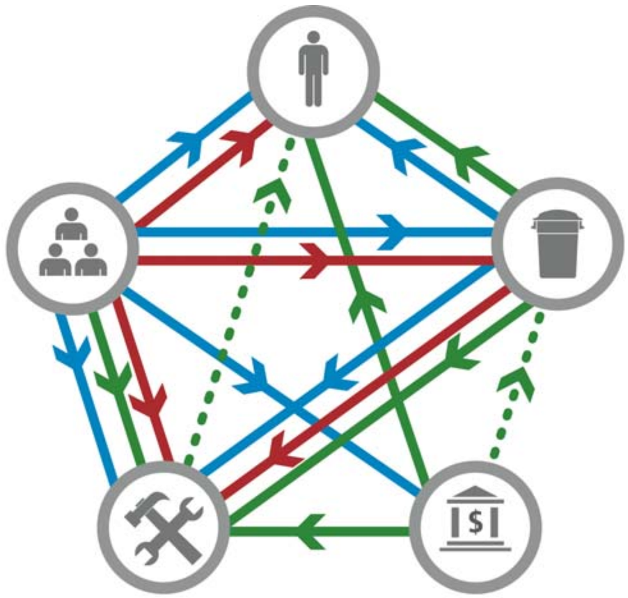


Figure 65. Air quality improvements hinge on reducing peak energy demands while moving towards increased renewable energy capacity across Ontario.



Solid Waste

Less solid waste (construction and post-occupancy)

GOVERNMENT

Provides tax credit for projects having effective solid waste management facilities.

Monitors solid waste generation and provides all stakeholders with reliable feedback on collective waste management behaviour.

Establishes comprehensive packaging and recycling regulations.

Educates public about 3Rs and composting.

UTILITIES

Diversify collection fleet to enable more flexible waste handling facilities and access routes in new developments.

Implement solid waste pricing structure that rewards appropriate developer (construction) and consumer behaviour.

Provide incentives to developer for all solid waste management facilities.

Implement solid waste management programs in all new developments with a focus on recycling and composting.

FINANCIAL (banks and insurance)

Provide lower interest rate loans to developers for all additional capital costs associated with waste management measures.

Provide lower interest rate loans, insurance premiums and extend mortgage eligibility to purchasers of properties complying with the TGDS.

Invest through ethical funds in recycling and bio-gas energy generation technologies.

DEVELOPER

Agrees to employ best practices for handling construction and demolition waste.

Agrees to design development to encourage recycling and composting in exchange for incentives.

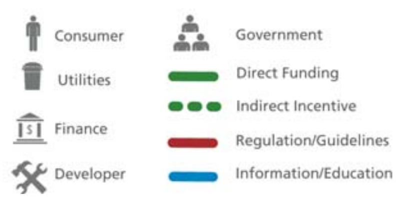
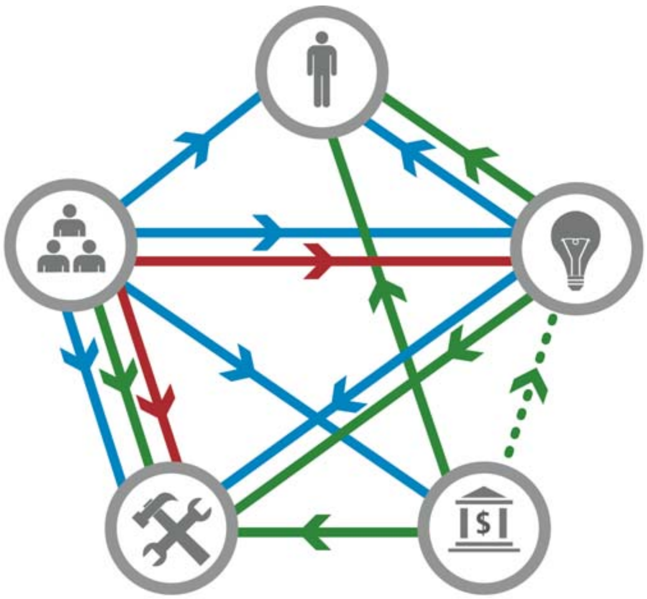


Figure 66. The management of solid waste requires that diversion is actively encouraged through design, policies and practices by rewarding recycling and composting and economically penalizing garbage.



Ecology

Protection of the urban forest, wildlife habitat and reduced light pollution

GOVERNMENT
Reduces development charges for projects implementing appropriate ecology measures.

Provides tax credit for projects that restore and preserve natural systems.

Establishes environmental plan and regulations.

Monitors forest canopy, biodiversity and light pollution to provides all stakeholders with reliable feedback on development impacts.

Educates public about benefits of trees, contiguous green spaces and reduced night lights.

UTILITIES
Offer incentives to developers for selecting eco-friendly exterior lighting.

Implement programs for changing over to more environmentally responsible street lighting.

FINANCIAL (banks and insurance)
Provide lower interest rate loans to developers for all additional capital costs associated with TGDS ecology measures.

Provide lower interest rate loans, insurance premiums and extend mortgage eligibility to purchasers of properties complying with the TGDS.

Invest through ethical funds in energy efficient and wildlife-friendly lighting technologies.

DEVELOPER
Agrees to implement appropriate ecology measures for entire development in exchange for incentives.

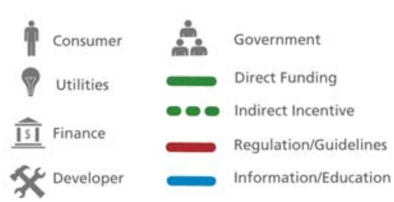


Figure 67. Planning developments that utilize brownfield and infill opportunities, rewarding environmentally responsible development, and monitoring the state of the environment are the primary instruments for improving our ecology.

A common driver among all of the key requirements underpinning the Toronto Green Development Standard is public awareness and education. How can consumers become as well educated about the performance of buildings as they are about the performance of automobiles, computers and home entertainment electronics? Implicit in this discussion is the notion of a rating that indicates the level of performance provided by a building. Practically everyone purchasing a car knows that a fuel consumption of 4.5 litres per 100 kilometres is twice as good as a rating of 9 litres per 100 kilometres. Similarly, an LCD television with a refresh rate of 120 Hertz is twice as fast processing images as another television with a 60 Hertz performance. Do people actually know what goes on under the hood and inside the electronic circuits or has industry undertaken to educate the public, much in the same way as children are taught about the meaning of traffic light colours without having to know anything about the technology of traffic light fixtures and controls?

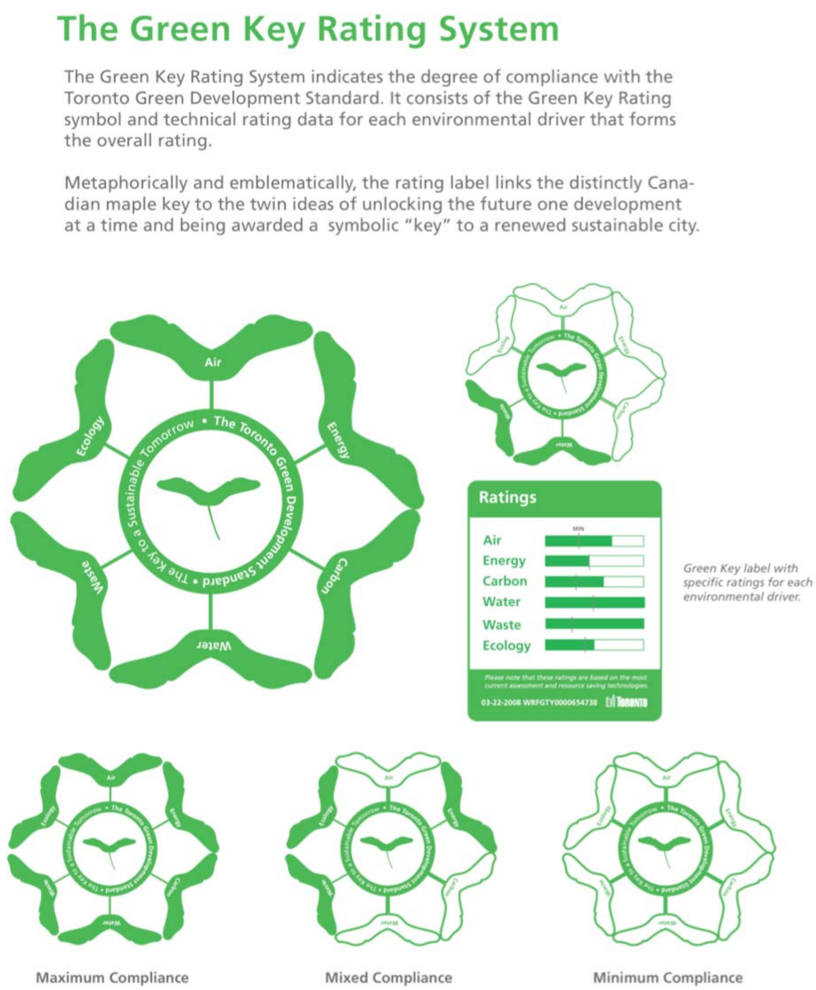


Figure 68. Example of a TGDS rating system label. Similar to restaurants, the ratings are periodically updated and published on the Internet.

Without consumer education, the most essential driver in the development marketplace is absent, making it impossible for consumers to make informed choices, for developers to market superior performing technology, and for utilities and financial institutions to offer appropriate incentives. Quantification is the key to commerce, much in the same way as education is the key to sustainability.

A part of this study examined the possible means of developing web-based tools for informing and educating the public about green development. A concept for a web-based assessment tool may be found in Appendix E of this report. It demonstrates how the Green Key rating system could be effectively explained, while providing a portal to an inventory of buildings that comply with the Toronto Green Development Standard. The web-based tool could also be integrated within the education system so that environmental awareness could extend beyond why we need to be sustainable, and go on to explain how we can make sustainable choices. Today, virtually every industry comparable in annual sales to the development industry is supported by web-based public education resources. Given the enormous profits enjoyed over the past decade across the GTAH, the development industry can generously afford to fund a third party agency to develop and maintain a world class web site that contains objective and authoritative information about green development.

Synopsis

Can the Toronto Green Development Standard achieve the benefits identified in this study? Looking at the net present value of potential benefits suggests it would be difficult not to attain some form of improvement over the present state of the economy, the environment and society. But how are the full benefits realized without overrunning costs and becoming entangled in regulatory and bureaucratic structures that smother innovation?

The present situation being faced by all developed nations, and specifically urban settlements along the Great Lakes, has come about as a complex interplay of economic and social drivers that did not factor the environment into their balance sheets. Consumption and consumption alone made for economic growth. The drivers were not consciously developed, rather they evolved from a frontier mentality that viewed nature as an endless resource to be conquered and exploited.

Now that we recognize our limits to growth and the fragility of the ecosystem, it is necessary to imagine a more sustainable model of development. From a culture of consumption, we can transition to a culture of conservation and cultivation. This will require that we carefully design the key drivers of sustainability so that fundamental economics reflect social aspirations and environmental imperatives.

The section that follows presents conclusions and recommendations of this study aimed at establishing a proactive framework for the effective implementation and evolution of the Toronto Green Development Standard.

Conclusions and Recommendations

This final section of the study is intended to highlight the significant findings and to provide a number of recommendations based on these findings. It includes ideas obtained from various stakeholders and experts, as accessed through their publications and, in many cases, personally. It is important to emphasize that these are the conclusions and recommendations of the study team, and do necessarily reflect the views of the City of Toronto, the Ontario Centres for Excellence, the Federation of Canadian Municipalities, and the steering committee members.

The conclusions are presented in the order of the findings as they appear in the study, and not necessarily prioritized. The recommendations are broken down into several categories: the Toronto Green Development Standard; the City of Toronto, provincial and federal governments; the development industry; and consumers.

Major Conclusions of the Study

Based on the research and analysis conducted in this study, the following conclusions have been summarized below:

1. The Toronto Green Development Standard is among a number of instruments being developed by the City of Toronto to mitigate adverse environmental impacts related to growth and development. It is important to recognize the TGDS is not intended to address all mechanisms and issues related to sustainable development. It has instead been based on a bio-regional approach to green development that recognizes the unique ecosystem that Toronto shares with the numerous communities that border the Great Lakes.
2. Population forecasts for the Greater Toronto Area and Hamilton indicate that the current population of 6.06 million inhabitants, based on 2006 census data, will increase to 8.62 million by 2031. Over 1 million new jobs will be created during this time period. Unless future developments provide opportunities for workers to live near their place of employment, or be connected to it by an efficient public transportation system, vehicular traffic in the GTAH is likely to become more congested, and this will in turn impact greenhouse gas emissions and air quality. Demands for energy, water, solid waste management, new housing, municipal infrastructure and social services may be expected to grow according to the ‘business as usual’ scenario that has been witnessed over the past decade, unless sustainable development is seriously pursued by all levels of government and across all sectors of the economy.
3. The new development being targeted through the TGDS is the tip of the built environment iceberg, simply because the existing built environment outnumbers the expected new growth. Existing buildings and infrastructure are far less energy efficient than even the least efficient of today’s developments, exerting a larger environmental footprint on a unit area basis. The impetus for new development to drive towards a more sustainable built environment will likely exert a strong influence on the retrofit of existing buildings, and the industries that contribute to urban regeneration.
4. A review of a large number of recent cost-benefit studies examining green buildings has concluded the capital cost premium ranges from between 2% to 7% of construction expenditures, with many projects examined in these studies having attained green building certification at no cost premium whatsoever. The majority of these studies may be considered conservative in their estimate of benefits because they have not examined the full economic, social and environmental benefits associated with green development, particularly impacts on municipal infrastructure.

5. The construction and development industry does not appear in any Canadian R&D statistics, but if this $74 billion a year industry had invested at the national average rate for R&D in 2006, some $1.4 billion in funding would have been available annually to improve productivity and technology. The costs and benefits reported in this and other studies are based on an industry employing a 20th century business model. It is reasonable to expect that similar gains in cost effectiveness enjoyed by other industry sectors could be realized for the green development industry through appropriate R&D investments.
6. It is premature to assume there exists a broad social consensus on appropriate yardsticks for measuring the costs and benefits of green development. Sustainability is a recently re-discovered concept for the average person and there remain sharp differences in opinions among bona fide experts in the field of sustainable development as how to best measure alternative approaches to addressing the economic, social and environmental bottom lines. However, it is generally agreed that for green building technology, economic measures such as payback and internal rate of return are inappropriate, as they do not consider the building life cycle. The use of life cycle costing to inform standards, regulations and policies is the most appropriate means of addressing the interests of all stakeholders.
7. For the period 2001 to 2006, Statistics Canada reports $52.96 billion in residential building permits and $29.67 billion in building permits for commercial and institutional buildings were issued. The vast majority of these buildings are neither energy efficient nor green as defined by the TGDS.
8. Energy simulations conducted on typical condominium buildings being constructed in the GTA indicated the energy consumption of a baseline building was almost 24% higher than permitted to comply with the minimum energy efficiency requirements of the Ontario Building Code. More sophisticated methods of checking compliance are needed to ensure that the higher levels of energy efficiency required under the TGDS are realized. As a minimum, effective thermal resistance values of walls, roofs, windows and glazing should be employed during compliance checks. Computerized building energy analysis by engineering consultants represents better practice that is now accessible and affordable.
9. For a typical multi-unit residential building (MURB), such as an apartment building or condominium, the cost-benefit assessment conducted in this study indicates that complying with the requirements of the TGDS represents less than a 2% capital cost premium yielding a payback period less than 7 years, and a return on investment exceeding 20%. Using life cycle cost measures, energy economics alone justify substantially higher investments in building fabric and HVAC systems that are highly cost effective and greatly reduce the ecological footprint of new developments.
10. An important factor emerging from life cycle analysis is the need to reconcile justifiably higher initial costs with mortgage eligibility. Clearly, the energy savings can finance the higher initial costs however, this economic relationship must be acknowledged by financial institutions and mortgage insurance agencies through their policies and practices.
11. Market research indicates there is pent up demand for offices in the Greater Toronto Area & Hamilton (GTAH) and high levels of office building construction activity are forecast over the next few years. Opportunities to advance green office building practices are ideally positioned as the demand for technically and environmentally advanced buildings is increasing among a commercial sector that is competing internationally to attract and retain knowledge workers.

12. For typical office buildings, complying with the requirements of the TGDS represents less than a 5% capital cost premium yielding a payback period averaging 6 years, and a return on investment averaging approximately 25%. The energy savings can leverage between a 15% to 20% cost premium based on life cycle economics, without considering incentives for reductions in greenhouse gas emissions and peak electrical energy demands. Cost-benefit analyses for offices demonstrate that energy savings alone afford generous margins for additional investments in durable and efficient building systems.
13. Recent statistics indicate that the shopping centre industry makes a significant contribution to the Canadian economy and exerts a strong influence on the urban landscape. Looking at developments over 40,000 square feet in floor area, in 2006 there were 2,345 shopping centres across Canada. Together, these accounted for $256.7 billion in sales (65.6% of total retail sales in Canada) and employed approximately 149,500 workers. The predominant contributor to the overall ecological footprint of retail/commercial developments is related to energy consumption, asphalt-paved parking lots and bright illumination.
14. For typical retail/commercial developments the costs of complying with the TGDS is in the range of 2%, offering a payback period averaging less than 5 years and yielding a return on investment averaging slightly more than 30%. Based on life cycle economics, the energy savings alone can leverage between a 12% to 15% cost premium, or roughly 6 to 7 times the cost premium associated with complying with the TGDS. Additional benefits are available through the integration of landscape and stormwater management systems. It is important to note that recent experiences for LEED certified retail developments have found a 7% to 8% construction cost premium in the absence of incentives.
15. Across the GTAH, TGDS requirements for low-rise residential developments have already been demonstrated to be cost effective by the Energy Star for New Houses program in Ontario. This integrated design, construction and commissioning model has achieved high levels of energy and water efficiency in new housing developments without compromising affordability. It serves as an example of how other building industry sectors can deliver performance labeling, third part quality assurance and cost effective green development.
16. This study concludes that the Toronto Green Development Standard requirements for water quality (stormwater management) can be achieved cost effectively with no financial burden to developers, consumers and municipalities. All indications point to lowering initial and lifecycle costs while providing measures for improving water quality exhibiting a higher environmental effectiveness.
17. Water conservation requirements in the TGDS are highly cost effective when the energy related costs (pumping, heating, in the case of domestic hot water, and treatment), and avoided costs for water treatment and sewage treatment plant expansion are considered.
18. Solid waste management requirements in the Toronto Green Development Standard are cost effectively achievable, but remain highly dependent on individual behaviour. A major issue to be reconciled is whether landfilling of solid waste that cannot be recycled or composted is preferable to waste-to-energy systems.
19. Renewable energy and district energy systems are sustainable energy technologies and infrastructure platforms. Their cost-effectiveness is rapidly improving with increased production and technological innovation. As the full cost accounting for conventional energy systems is being critically assessed, the lack of mandatory requirements for renewable energy in the TGDS is inconsistent with policies and regulations implemented in many international jurisdictions actively pursuing sustainable development.

20. TGDS requirements related to ecology do not pose any economic or technical barriers to implementation. The protection of the urban forest, wildlife habitats and the reduction of light pollution are initiatives that go beyond green development and speak to a larger set of social and environmental aspirations in urban settlements around the world.
21. Opportunities stemming from green development, both technological and knowledge-based, are significant and extend across the entire Greater Golden Horseshoe Region. It is forecast that by 2030, the renewable energy and energy efficiency (RE&EE) industry could account for approximately $95 billion annual revenues and provide 838,000 jobs. A deeper commitment to sustainability could generate about $180 billion in annual revenues and 1.6 million jobs. The vast majority of these jobs and revenues would be situated in the Greater Golden Horseshoe Region.
22. A green development future is at risk of being severely compromised by the lack of a suitably qualified and knowledgeable workforce. In the GTAH, there is presently insufficient architecture, engineering and construction (AEC) industry capacity to ensure all new development complies with the requirements of the Toronto Green Development Standard. Professional development programs and recruitment represent pivotal strategies that must be undertaken immediately.
23. In the green development industry, designers and constructors are the key knowledge workers needed to execute building projects. Architects, engineers, landscape architects and project managers work alongside quantity surveyors, building scientists and specification writers to define not just what is to be built, and how it is to be built, but more importantly, how it will perform in relation to codes, standards and societal expectations. Without this 'creative class' of the architecture, engineering and construction industry, green development will remain an unrealized aspiration.
24. The supporting actors in this epic of sustainable development are the skilled workers who layout, construct and commission the buildings and supporting infrastructure. These are rapidly becoming an endangered species in a world where much higher status and prestige are attached to knowledge workers. Nearly 50,000 workers in the Ontario construction industry are set to retire in the next several years and there does not appear to be a credible replacement strategy in place at the provincial level.
25. The costs and benefits of energy conservation represent the largest impacts associated with implementation of the Toronto Green Development Standard. This is followed by impacts related to urban and energy infrastructure.
26. The net present value of benefits associated with the Toronto Green Development Standard total $17.46 billion under the current energy price escalation scenario, and $21.19 billion under the high scenario for the period 2007-2031. This grows to $36.24 billion and $46.92 billion respectively, under the two scenarios for the period 2032-2056. By the end of the useful life of the building development during 2007-2031, the net benefits realized range from $66.14 billion under the current energy price escalation scenario, and $131.03 billion under the high scenario for the period 2057-2081.
27. Alternatively, these amounts represent the net present values of future burdens placed on succeeding generations if the '*business as usual*' development model persists for the next 25 years.
28. This study concludes that green development as envisioned in the Toronto Green Development Standard is a cost effective approach to achieving a sustainable future that poses no real economic hardships on any of the stakeholders. To remain effective in the long term, it must evolve to meaningfully respond to social, economic and environmental realities.

Recommendations

This study has considered a large number and variety of issues, opportunities and barriers associated with green development. Sustainability involves a complex interplay of social, economic and environmental factors that have to be effectively integrated to guide our common future. The following recommendations have been prepared for consideration by all stakeholders interested in taking the green development path.

Toronto Green Development Standard

1. While it appreciated that the TGDS seeks to involve the largest number of green development stakeholders, this cost-benefit study indicates that requirements for energy and water conservations should be significantly strengthened. A large margin of cost effective improvement remains feasible, especially given the recent increase in oil prices.
2. Requirements for renewable energy and green roof technology should be tailored to advance both of these important green development agendas. Some component of either or both technologies should be required under the TGDS in order to develop industry capability, foster innovation, and normalize their deployment in all new developments. All government sectors and utilities should provide incentives for developers to invest in new technology.
3. Life cycle cost measures as demonstrated in this study should form the sole basis for determining cost effectiveness. A minimum study period of 25 years that takes into account externalities and avoided costs should be employed in determining all subsequent revisions to the TGDS.
4. As part of a TGDS implementation strategy, a performance labeling program should be developed and made mandatory to encourage and reward innovation for the development industry, inform and protect consumers, and provide reliable information to financial institutions and utilities planning appropriate incentives. This will indicate performance above minimum TGDS requirements and offer a marketing advantage to progressive developers. A consensus-based standard for performance labeling conforming to the protocol approved by the Standards Council of Canada, remains a logical means of standardizing performance data that can be effectively conveyed to all stakeholders.
5. In keeping with current practices developed by the European Union, the TGDS should require all new developments and all substantially retrofit developments to publicly disclose energy, water and waste statistics. Without these data, the correlation between estimated and actual building performance cannot be established to assure reliable ratings, and inform future revisions to TGDS requirements. Utilities and the City posses these data, and permission for disclosure could be a pre-condition for obtaining approvals and permits. These data could be used to establish the Green Key ratings, which would indicate actual performance and be available for new and existing buildings.
6. The TGDS should be revised periodically to reflect technological innovation, and the latest and newly forecast social, economic and environmental factors impacting thresholds of sustainable development. An integrated cost-benefit model coordinated among all relevant City of Toronto departments should inform the standard's development, maintenance, and implementation process. The framework for an integrated cost-benefit model has been developed in this study whereby data from various City departments, utilities and Statistics Canada could be assembled within the model on an annual basis. A periodic survey of green development cost premiums would have to be conducted and compared with the actual performance data gathered as per the previous recommendation. A society is only as sustainable as its knowledge base, information is king and government must lead by example.

City of Toronto, Provincial and Federal Governments

1. A central agency to coordinate all incentives, grants and subsidies associated with green development is needed to streamline these processes on behalf of the development industry. A single application should automatically engage all eligible programs available to developers.
2. Consumer education in relation to building performance is needed to enable informed choice and stimulate green development. Programs for the energy and environmental performance of buildings should be developed at the primary, secondary, and post-secondary levels. Public broadcasting through radio, television and the Internet must inform consumers about what to look for and why it is critical when buying a new home or condominium, or renting or leasing office and retail space. Concepts like life cycle costing need to be simply explained using techniques championed by the automotive, computer and home entertainment industries.
3. The energy and environmental performance of all government buildings, facilities and services must be expertly assessed and publicly reported to establish a performance labeling protocol and establish a market for the gainful employment of energy performance certification personnel. Leadership by all levels of government is needed to demonstrate appropriate practices to the development industry.
4. A comprehensive skilled trades training and education program is needed to provide the renewable energy and energy efficiency industry with suitably qualified workers and respond proactively to forecast demand.
5. Professional development for architects, engineers, constructors and regulatory officials is needed to ensure sufficient capability and capacity to respond to the forecast demand for high performance green buildings. Education programs in building science, building performance simulation, construction management and quality control/assurance are needed to upgrade existing professionals and qualify upcoming candidates seeking a future in the AEC industry.
6. A deeper commitment to renewable energy and landscape infrastructure technologies should be demonstrated by all levels of government. Every government building and retrofit should include a significant component of renewable energy technology to demonstrate its feasibility and stimulate this industry sector. Green roofs and landscape infrastructure technologies should be incorporated into every government facility, new and retrofit, and rigorously monitored to provide designers and regulators with authoritative data on actual performance.
7. For all government-regulated utilities, financial incentives to encourage green development should not take the form of cash rebates. Instead, the utility should fund the equivalent value of the rebates or incentives in the form of installed renewable energy capacity, either on site or elsewhere within the energy system. This measure has two effects: it enables the aggregation of renewable energy purchasing, installation, commissioning, operation and maintenance for greater economy; and it removes the burden of renewable energy implementation from the developer and places it on the capable shoulders of its primary beneficiary.
8. All three levels of government are encouraged to provide research funding for the social, economic and environmental aspects of green development and the City of Toronto is encouraged to host an annual conference on sustainable urban development to exchange the latest information and ideas, and how these have been explored and implemented in its own jurisdiction.

Development Industry

1. The development industry in the GTAH is encouraged to move toward performance based contracting to ensure that design, construction and commissioning of new building developments attain the required levels of performance.
2. It is not fair to consumers that unlike the automotive, computer and entertainment electronics industries, the development industry directs none of its profits to research and development that improves product quality while reducing prices. In real dollars, the cost and performance of new buildings pales in comparison to virtually every other consumer goods sector. The development industry is encouraged to invest at the average level of the other Canadian industry sectors in R&D annually to improve productivity, enhance performance and reduce prices.
3. It is highly recommended that the development industry join with government in the funding of skills training and professional upgrading needed to make a smooth transition to the green development model. Public education campaigns in the real estate sections of newspapers and the training of real estate agents are among the many initiatives that will assist developers explain the justifiable premiums for green developments and how these translate into cost effective investments over the life cycle of the buildings.
4. On March 2, 2007, the Vancouver Valuation Accord marked an agreement to address the interrelationship of sustainability and value in real estate assets. The GTAH development industry is encouraged to promote the implementation of progressive valuation principles among all stakeholders so the true value of green development is recognized by consumers, investors and financial institutions.
5. Greenhouse gas credits should be aggregated by the development industry and the proceeds used to fund an extraordinary series of scholarships and bursaries to foster the education of the green development industry's leaders of tomorrow.

Consumers

1. Consumers require reliable information upon which to base decisions, especially decisions regarding what is usually their largest lifetime investment. It is recommended that consumers lobby government for mandatory performance labeling of buildings conforming to procedures and protocols developed within a consensus-based standard that serves all stakeholders.
2. Building technology is complex, and aspects of green building development may be more complex. Consumers should lobby government to develop and deliver appropriate public education programs so that consumers can understand the significance of performance ratings and their choices of building technologies.
3. The influence of consumer behaviour on energy use, water consumption and waste generation is a major variable determining our collective ecological footprint. Consumer protection and advocacy organizations are encouraged to inform the public about alternatives to consumption that promote a society of conservation and cultivation.

This cost-benefit study represents a picture of a frozen moment in time. It is vitally important that the process of assessment and valuation becomes institutionalized so that green development and the many processes that support it become the new business as usual. Sustainability demands re-examination, reflection and regeneration.

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