ENVIRONMENTAL IMPROVEMENT THROUGH URBAN ENERGY MANAGEMENT

CANADIAN OVERVIEW

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Executive Summary

This paper reviews the rationale for and the current practice of urban energy management in Canada, with a particular focus on the environmental benefits. It describes the results of a survey of urban energy management for environmental improvement in Canada, with an emphasis on best practice and illustrations of innovative programmes. Observations are made with regard to the reasons Canadian municipalities are adopting urban energy management programmes, the barriers they are encountering, and the common elements essential to success. The appendices contain background material on the supply and demand of fuels and electricity in Canada and the related environmental impacts, with particular reference to urban energy and environment issues.

Multiple Benefits

Energy management is moving up the local government agenda in Canada, both as a management issue and policy issue. On the management side, the prospect of saving money on their fuel and electricity bills is often the starting point for municipal energy saving initiatives. Municipalities are major players in the energy economy with a collective energy bill in the range of $1 billion. Energy is emerging as a strategic target as city managers face increasing pressure to reduce operating expenditures.

On the policy side, there is renewed interest in community-wide energy management as a means of contributing to economic, environmental and social development goals. In addition to the direct financial gains, urban energy management contributes to job creation, local economic development, cleaner air, reduced greenhouse gas emissions and other environmental improvements.

This survey of current activities revealed that urban energy management is practiced in Canada at three stages or levels.

Level One: In-House Energy Management

Level One consists of efforts to reduce the fuel and electricity use of the municipality's own operations. This is the most prevalent form of urban energy management in Canada. It is motivated by the related financial savings, and is under the direct control of municipal professional staff. With few exceptions, simple payback criteria are used to screen candidate measures and relatively fast paybacks are demanded (usually less than three years, rarely more than five).

Examples:

To overcome the problem of the quick payback demanded by cash-poor line departments for energy management measures, in 1990 the City of Regina established the "Special Initiative Investment Program". The program is essentially an internal revolving fund (initially allocated $250,000) from which city departments may borrow savings. Initiatives financed by the fund must be able to repay the fund at rates equivalent to what the money could have earned if invested in the market place. This allows much greater levels of energy efficiency to be pursued than is possible with simple paybacks of two or three years.

The City of Vancouver has also had an internal energy conservation program since 1977 and the accumulated savings of measures implemented as part of this program are now more than $1.5 million per year. Like Regina, they have solved the problem of "up-front" financing costs for energy conservation measures by making "in-house" loans available. The city's finance department arranges funding for energy conservation projects and retrofits thought the Property Endowment Fund, which is repaid with interest from the savings in fuel and electricity costs.

Level Two: Urban Energy Management

The second level of urban energy management represents an intermediate stage between in-house conservation programs and strategic urban energy management for environmental improvement. In Level Two energy management, programs are extended to the community-at-large, but environmental improvement is not a primary goal. Programs can be mounted in partnership with utilities seeking to achieve demand side management targets in the urban market, or with other levels of government to achieve policy goals related to energy security, employment, or economic development.

Example:

The Town of Espanola and Ontario Hydro have illustrated the potential for municipal partnerships with electric utilities. Over the two year implementation phase of the project, the utility contributed $4.2 million toward the energy management measures and the community share totalled $2.1 million. In addition, it is estimated that there was an additional $600,000 invested by the community in measures directly related to the retrofit activity but which were not eligible for the utility incentives. Of the 87% of homes and businesses that received an audit, 72% of the kW.h value of the measures recommended for all homes have been accepted. A total of about 8,000,000 kW.h per year in savings has been attributed to the program, reducing the collective electricity bill in the community of 5,400 by nearly $600,000 per year.

Level Three: Urban Energy Management for Environmental Improvement

The most advanced stage of urban energy management involves the integration of urban energy management into strategies for environmentally sustainable community development. At this stage, energy management programmes are broadly based in the community and comprehensive in their coverage of sectors and end users. As well as initiatives to promote energy efficiency and renewable energy in the infrastructure, buildings, and vehicles throughout the community, considerations of energy and environmental sustainability are integrated into urban form and land use planning. The multiple benefits of energy management are stressed in the marketing of Level Three initiatives, and program delivery is coordinated with related programs for waste reduction and recycling, water management and sustainable urban transportation.

Example:

Toronto was the first city in the world to make a commitment to reducing carbon dioxide emissions on a city-wide basis and has taken a number of initiatives toward that goal in the last several years such as the creation of the $25 million Toronto Atmospheric Fund, the establishment of an Energy Efficiency Office, a program of retrofits of city buildings, and studies of the energy management potential in the community.

Looking toward the future, Toronto's proposed **Green Economic Initiative** represents the most advanced approach being taken to urban energy management for environmental improvement in Canada. It includes innovative features to overcome the barriers that typically face urban energy management initiatives and it combines all the positive elements of sustainable urban economic development -- community involvement, environmental targets, business partnership, innovative financing, comprehensive coverage, integrated programs, and political leadership.

The goal of the Green Economic Initiative is to retrofit every home and business in the City of Toronto. A participation rate of 75% is targeted, and if successful the total investment will be about $3 billion when the project is finished.

Obstacles to Energy Management for Environmental Improvement

The review of current energy management practices in Canada also revealed a number of obstacles to urban energy management for environmental improvement in Canadian cities; the following list itemizes the more important and pervasive ones.

- Failure to Realize the Possibilities
- Constitutional and Legal Barriers
- Information Gaps
- Lack of Analytical Capacity
- Financial Constraints

Keys to Success

Finally and most importantly, the survey of current practice showed that successful programs for urban energy management share a number of key elements:

- A Strategic Approach
- Environmental Targets
- Recognition of Multiple Benefits
- Political Leadership
- Community Involvement
- Bureaucratic Support

- Partnership
- Innovative Financing
- Collaboration with Other Local Governments
- Integrated Program Delivery

The opportunity for municipal governments to become significant players in urban energy management for environmental improvement has only recently been identified, and true urban energy management for environmental improvement is in its early stages in Canada. Nevertheless, there are already some outstanding innovations among the efforts that have been mounted to date, and there are a number of very exciting initiatives at the development stage.

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Note:

This Canadian Overview was prepared by Torrie Smith Associates for Canada Mortgage and Housing Corporation. It was provided as Canada's input to the Project Group "Environmental Improvement through Urban Energy Management", of the OECD Group on Urban Affairs. The final report of the Project Group, which includes five case studies from the Canadian Overview, was published by the OECD under the title **Urban Energy Handbook -- Good Local Practise.**

Ce document est également disponible en français de la SCHL sous le titre **Améloration de l'énvironnement par la gestion de l'énergie dans les villes - Perspectives canadiennes.**

AMÉLIORATION DE L'ENVIRONNEMENT PAR LA GESTION DE L'ÉNERGIE DANS LES VILLES

PERSPECTIVES CANADIENNES

RÉSUMÉ

Ce document fait état du bien-fondé de la gestion de l'énergie dans les villes canadiennes et des pratiques courantes dans ce domaine, en insistant particulièrement sur les avantages environnementaux. Il donne les résultats d'une étude traitant de l'amélioration de l'environnement par la gestion de l'énergie dans les villes canadiennes, privilégiant les pratiques les plus efficaces et les bienfaits de programmes innovateurs. Il formule également des observations quant aux raisons pour lesquelles les municipalités canadiennes font appel aux programmes de gestion de l'énergie, traite des obstacles que les municipalités doivent surmonter ainsi que des aspects communs essentiels à la réussite. Les annexes contiennent de la documentation concernant l'offre et la demande de combustibles et d'électricité au Canada de même que les répercussions sur l'environnement, se référant particulièrement à l'énergie en milieu urbain et au dossier de l'environnement.

Avantages multiples

Au Canada, la gestion de l'énergie occupe de plus en plus de place à l'échelon municipal, tant au point de vue de la gestion que les questions de principes. Côté gestion, la perspective d'économiser sur les frais d'électricité et de combustibles est souvent l'élément déclencheur qui motive les municipalités à se tourner vers des mesures d'économie d'énergie. Les municipalités ont un rôle important à jouer en ce qui a trait à l'économie d'énergie puisque l'ensemble de leurs factures de consommation d'énergie représente une somme de l'ordre de un milliard de dollars. L'énergie apparaît comme une cible stratégique car les gestionnaires municipaux sont de plus en plus contraints de réduire les dépenses d'exploitation.

Pour ce qui est des questions de principes, il y a un intérêt renouvelé pour la gestion de l'énergie dans l'ensemble des collectivités. C'est une façon de contribuer à la poursuite des objectifs en matière d'économie, d'environnement et de développement social. En plus de susciter des gains financiers directs, la gestion de l'énergie favorise la création d'emploi, le développement économique local, l'assainissement de l'air, la diminution de l'émission de gaz qui entraînent l'effet de serre ainsi que d'autres améliorations relatives à l'environnement.

Cette étude sur les activités courantes révèle que la gestion de l'énergie dans les villes canadiennes se pratique à trois niveaux :

Premier niveau : Gestion interne de l'énergie

Le premier niveau regroupe les efforts visant à diminuer la consommation de combustibles et d'électricité destinée aux propres activités d'une municipalité. Il s'agit du mode de gestion de l'énergie dans les villes le

plus répandu au Canada. Il est motivé par les économies financières connexes et relève directement des spécialistes municipaux. À quelques exceptions près, on utilise de simples critères de récupération pour évaluer les mesures possibles et l'on exige des périodes de récupération relativement courtes (habituellement moins de trois ans, rarement plus de cinq).

Exemples

Pour surmonter le problème du court délai de récupération que les services opérationnels à court de fonds exigent des mesures de gestion de l'énergie, la ville de Regina a créé en 1990 le Spécial Initiative Investment Program qui se veut essentiellement un fond renouvelable interne (fixé initialement à 250 000 $) où les services municipaux peuvent emprunter les montants nécessaires aux mesures d'efficacité énergétique. Les emprunts sont ensuite remboursés, avec intérêts, à l'aide des économies réalisées. Les projets ainsi financés doivent permettre de rembourser le fonds moyennant un taux de rendement équivalent à celui du marché, d'où l'atteinte d'une meilleure efficacité énergétique que dans le cas d'une période de récupération de deux ou trois ans.

La ville de Vancouver dispose d'un programme interne d'économie d'énergie depuis 1977. Les économies cumulatives des mesures mise en place dans le cadre du programme s'élèvent maintenant à plus de 1 500 000 $ par année. Comme Regina, Vancouver a résolu le problème du financement de démarrage des mesures d'économie d'énergie en consentant elle-même des prêts. Grâce au Property Endowment Fund, le service des finances de la ville assure le financement des projets d'économie d'énergie et des travaux de rattrapage. Le remboursement s'effectue à partir de l'intérêt découlant des économies réalisées sur les frais d'électricité et de combustibles.

Deuxième niveau : Gestion de l'énergie dans les villes

Le deuxième niveau de gestion représente une étape intermédiaire entre les programmes de conservation internes et la gestion stratégique de l'énergie dans les villes orientée vers la protection de l'environnement. Les programmes de gestion de l'énergie du deuxième niveau sont étendus à l'ensemble de la collectivité, mais la protection de l'environnement n'est pas leur principal objet. Les programmes peuvent être mis sur pied en association avec des services publics à la poursuite d'objectifs de gestion de la demande sur le marché urbain, ou encore, avec d'autres paliers de gouvernement pour atteindre des objectifs de politique ayant trait à la sûreté de l'énergie, à l'emploi ou au développement économique.

Exemple

La municipalité d'Espanola et Ontario Hydro ont illustré les possibilités de partenariat entre les municipalités et les entreprises publiques de production d'électricité. Pendant les deux années de la mise en oeuvre du programme, Ontario Hydron a consacré 4 200 000 $ aux mesures de gestion de l'énergie, alors que la part de la collectivité s'est élevée à 2 100 000 $. De plus, on estime que la collectivité a investi 600

000 $ de plus pour des travaux de rattrapage qui n'étaient pas admissibles aux incitatifs de la société de services publics. Des 87 % de maisons et d'entreprises ayant fait l'objet d'une vérification, la valeur en kWh des mesures recommandées pour toutes les maisons a été acceptée dans 82 % des cas. On attribue au programme une économie annuelle totale d'environ 8 000 000 de kWh, ce qui diminue la facture d'électricité de la collectivité de 5 400 habitants de près de 600 000 $ par année.

Troisième niveau : L'amélioration de l'environnement par la gestion de l'énergie dans les villes

La troisième étape de la gestion de l'énergie dans les villes prévoit l'intégration de cette dernière à des stratégies de développement communautaire écologique. À cette étape, les programmes de gestion de l'énergie sont largement implantés dans la collectivité et ils englobent tous les secteurs et les utilisations finales. Tout comme les initiatives destinées à promouvoir l'efficacité énergétique et l'énergie renouvelable dans les infrastructures, les bâtiments et les véhicules de toute la collectivité, les considérations touchant l'énergie et l'écologie sont incorporées à la formule du milieu urbain et au plan d'occupation des sols. Les multiples avantages de la gestion de l'énergie sont mis en évidence au cours de la commercialisation des initiatives du troisième niveau et la mise en oeuvre du programme est coordonnée avec des programmes connexes de réduction des déchets et de recyclage, de gestion de l'eau et de transport urbain écologique.

Exemple

Toronto a été la première ville du monde à s'engager à diminuer les émissions de gaz carbonique sur l'ensemble de son territoire. Ces dernières années, elle a pris un certain nombre de mesures à cette fin, telles la création du Toronto Atmosphérique Fund de 25 000 000 $, la mise sur pied de l'Energy Efficiency Office, un programme de rattrapage axé sur les bâtiments municipaux et des études concernant le potentiel de gestion de l'énergie dans la collectivité.

Si l'on se tourne vers l'avenir, le projet **Green Economic Initiative** de Toronto présente l'approche la plus innovatrice en matière de gestion de l'énergie dans les villes axée sur la protection de l'environnement au Canada. Il comprend des caractéristiques nouvelles qui permettent de surmonter les obstacles qui nuisent habituellement aux initiatives de gestion de l'énergie dans les villes et il combine tous les éléments positifs du développement économique durable en milieu urbain - soit la participation des collectivités, les objectifs environnementaux, le partenariat d'entreprise, le financement innovateur, une protection complète, des programmes intégrés, et enfin, le leadership politique.

L'objectif de la Green Economic Initiative est d'améliorer l'efficacité énergétique de chaque domicile et entreprise de Toronto. On compte atteindre un taux de participation de 75 %. Si cet objectif est atteint, l'investissement total sera d'environ 3 milliards de dollars à l'achèvement du projet.

Obstacles à la gestion de l'énergie dans les villes axée sur la protection de l'environnement

L'examen des pratiques courantes en matière de gestion de l'énergie au Canada a également révélé un bon nombre d'obstacles à la gestion de l'énergie axée sur la protection de l'environnement des villes canadiennes. La liste suivante indique les plus importants :

* Incapacité de saisir les possibilités
* Obstacles constitutionnels et juridiques
* Lacunes en matière d'information
* Absence de capacité d'analyse
* Contraintes financières

Facteurs de réussite

Finalement, le facteur le plus important : l'enquête sur les pratiques courantes a montré que les programmes efficaces de gestion de l'énergie dans les villes ont des éléments clés en commun :

* Une approche stratégique
* Des objectifs environnementaux
* Reconnaissance de l'existence d'avantages multiples
* Leadership politique
* Participation de la collectivité
* Soutien de la bureaucratie
* Partenariats
* Financement innovateur
* Collaboration avec les autres administrations locales
* Mise en oeuvre intégrée des programmes

Ce n'est que dernièrement que l'on a constaté que les autorités municipales pouvaient avoir un rôle de premier plan à jouer en ce qui a trait à la gestion de l'énergie axée sur la protection de l'environnement. La véritable gestion de l'énergie dans les villes en est à ses débuts au Canada. Déjà, des innovations remarquables ont marqué les efforts déployés jusqu'à présent, sans compter que d'autres très prometteuses sont en cours d'élaboration.

Nota : Cet aperçu de la situation au Canada a été préparé par Torrie Smith Associates pour le compte de la Société canadienne d'hypothèques et de logement. Il représente l'apport du Canada au groupe de travail sur l'amélioration de l'environnement par la gestion de l'énergie dans les villes, lequel fait partie du Groupe des affaires urbaines de L'OCDE. La version finale du rapport du groupe de travail, qui regroupe cinq études de cas tirées de l'aperçu de la situation au Canada, a été publiée par L'OCDE sous le titre «L'énergie dans la ville : manuel de bonne gestion locale» .

1. INTRODUCTION

By 2010, world emissions of carbon dioxide, the major greenhouse gas, are projected to soar by 50 per cent over the 1990 level, unless further policy action is taken.

OECD Letter, Vol.3, No.7, August/September, 1994.

1.1 Background and Objectives

Most people live in cities and that is where most fuel and electricity consumption takes place. The air pollution caused by fuel combustion is therefore concentrated in urban areas. Air quality has become a priority concern of urban communities everywhere and global warming, essentially a result of the fossil-fuel-based energy system, has become an issue for all levels of government. In addition, other types of environmental stress caused by the production, transportation and final use of fuels and electricity occur in cities or are related to the levels and patterns of urban energy use. Energy conservation and the development of clean energy sources are key elements of the strategic response to the global environmental crisis.

At the same time, energy and environmental policy makers are recognizing the importance of local government participation in delivering the "demand side" and renewable energy policy objectives that are emerging as the key elements of strategies for sustainable energy development. Analogous to business organizational strategies that seek to "stay close to the customer", local governments' proximity to the electorate can make them more effective than higher levels of government, especially in the delivery of integrated policies and programmes that require adaptation to meet local circumstances. More than that, it is increasingly recognized that the level of demand for fuels and electricity in the society is determined to a large degree by urban form and land use patterns, both of which are largely determined by local government (provincial and municipal) policies.

In 1990, the Organization for Economic Cooperation and Development (OECD) Group on Urban Affairs published a report entitled "Environmental Policies for Cities in the 1990s". The report was a response both to the growing environmental concerns of urban governments and to the growing realization that changes at the local government level will be at least as important in the long run as state and national policies in achieving sustainable development. That report identified three main areas of concern: urban rehabilitation, urban transport and urban energy management.

In May 1991 the OECD approved the terms of reference for a Project Group on Environmental Improvement Through Urban Energy Management. Quoting from those terms of reference, "the project focuses on those issues of energy provision, and its environmental impact, which are most closely linked to urban design, urban management, the cooperation between institutions and economic sectors on the local level, and the involvement of public-private partnerships and of citizens themselves." More specifically, the project terms of reference identified the following priorities:

- The need to identify "urban synergies", defined as the result achieved by combining distinct efforts, forces or systems where the product of the combination of these elements is larger than the sum of the single elements.
- The need to exploit fully the potential of combined heat and power and district heating.
- The need to increase the proportion of renewables in urban energy supply.
- The need to activate consulting and training services in urban energy provision and energy consumption.
- The need to optimize energy efficiency in specific urban services.
- The need to consider the energy dimension in adjusting urban travel to the requirements of sustainable development.
- The need to develop a comprehensive accounting framework and urban indicators of environmental energy efficiency.
- The need to evaluate options for financing energy-related municipal investments and to assess their impacts on the local economy.

As part of the work of the Project on Urban Energy Management for Environmental Improvement, participating member countries were asked to prepare review papers describing the current approach and best practice with respect to the above issues. This paper has been prepared as part of Canada's contribution to the project.

It bears emphasizing at the outset that "urban energy management for environmental improvement" is a new idea in Canada and is not yet widely understood or practiced. On the other hand, there are individual examples of urban energy management in Canada which compare favourably with the most advanced approaches being taken anywhere and which should be of interest to both Canadian and international readers. This paper therefore has a dual purpose: firstly, to describe the rationale and basis for urban energy management in a Canadian context; secondly, to highlight and illustrate the best Canadian practice of urban energy management in a way that both informs and suggests a future strategic direction for local governments in Canada.

1.2 Organization of Paper

The next section contains some background material on the supply and demand of fuels and electricity in Canada and the related environmental impacts, with particular reference to urban energy and environment issues. This is followed by some additional background material on the role of local government in the Canadian political system. Section 3 describes the results of a survey of urban energy management for environmental improvement in Canada, with an emphasis on best practice and illustrations of particularly innovative programmes. Section 4 presents a number of general observations with regard to the reasons Canadian municipalities are adopting urban energy management programmes, the barriers they are encountering, and the common elements essential to success.

2. ENERGY, ENVIRONMENT AND LOCAL GOVERNMENT IN CANADA

2.1 Urban Energy Use and Environmental Impacts in Canada

Appendix A contains a description of Canadian energy use patterns and the associated environmental impacts. Virtually all the different types of environmental stress associated with either the production or the consumption of fuels and electricity are present to a greater or lesser degree in Canada. In terms of the direct environmental stress in *cities* from the energy system, the most important issues are those related to the burning of fossil fuels. In particular:

- Air pollution from fuel burning is perhaps the most widely recognized environmental impact of the energy system in urban areas where the concentration of people (and fuel burning) often leads to severely degraded and unhealthy local air quality. In fact, fuel combustion is the leading source of the most serious local air pollutants -- nitrogen oxides, volatile organic compounds, sulphur dioxides, and particulate matter.

- Fuel combustion also releases carbon dioxide, which does not pose a local air quality threat, but does contribute to the global greenhouse effect, considered one of the most serious international environmental problems. A number of Canadian cities have recognized a local responsibility for reducing greenhouse gas emissions and have made commitments to do so, including Victoria, Vancouver, Edmonton, Regina, Toronto, Metropolitan Toronto and Ottawa.

- The environmental impact of automobiles bears particular emphasis in a discussion of urban energy and environment. The automobile and its associated infrastructure represents not only the largest direct source of environmental stress in urban areas (from tailpipe emissions) but also the largest indirect driving force behind many other types of ecosystem stress found in cities that result from the land use patterns and urban forms associated with high levels of automobile dependence.

In addition to these impacts, there are many other environmental stresses caused by the production, transport and final use of energy, including environmental restructuring from hydroelectric development, radioactive waste and pollution from nuclear power development, air and water pollution from the primary energy production and refining industries, and the aesthetic and land use impacts of electric transmission lines and oil and gas pipelines. All the environmental impacts of the energy system are at issue in a consideration of urban energy management for environmental improvement. The final demand for energy services originates, for the most part, in cities, and so any gain from urban energy management that allows a particular task to be performed with less fuel or electricity will cause a reduction in environmental risk and ecological stress. This reduction in ecological stress occurs not only at the point of end use, but works its way "upstream" to the primary resource extraction, reducing environmental risks all along the way.

Urban Energy Demand Patterns

The most logical starting point for an analysis of urban energy management is a detailed breakdown of energy demand by fuel and by end-use. Unfortunately, in Canada (and in most other countries) information about the use of fuels and electricity is not collected or compiled at the urban level, and so it is difficult to develop a profile of urban energy use patterns in Canada. In the absence of a definitive database from which to develop such a profile, urban energy analysis requires that such profiles be developed "from the ground up", based on information about the level and variety of energy using activities in the city and the mix of fuels and technological efficiency with which those activities are carried out. The quality of the resultant profile is directly related to the level of resources devoted to this exercise and to the richness of the database available.

Efforts to develop profiles of urban energy use have been undertaken in three of Canada's large cities, all in Ontario -- the City of Toronto[1], the Regional

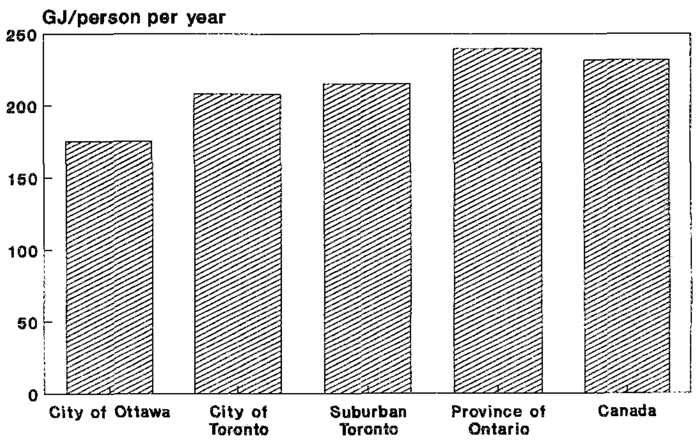
1. For the City of Toronto, data compiled from a series of studies done for the City of Toronto by Torrie Smith Associates and Marbek Resource Consultants under the generic titles City of Toronto Potential for Oil and Gas Conservation and City of Toronto Potential for Electricity Conservation, for the Office of Energy Efficiency, City of Toronto, 1990-1993. Transportation sector data was also taken from City of Toronto, Transportation and Land Use -- City of Toronto and the Municipality of Metropolitan Toronto, report prepared for the International Council for Local Environmental Initiatives, March 1992.

Municipality of Metropolitan Toronto[2] and the City of Ottawa[3], and in Table 1 the resulting profiles are compared with the corresponding provincial (Ontario) and national energy use statistics[4]. Based on the patterns evident in Table 1, combined with other analyses of urban energy patterns,[5] there are a number of conclusions that can be drawn about the unique aspects of urban energy demand.

First, as illustrated in Figure 1, per capita energy use in cities tends to be lower than for other settlement patterns or for the general population. Although density itself may not be the cause, there is a widely acknowledged inverse correlation between per capita energy use and population density. Cities are relatively efficient settlement patterns from an energy perspective; the reason there are such severe energy-related air quality problems in urban areas is not because per capita energy use is high but because there is such a high concentration of energy use relative to the capacity of the local airshed to absorb and recover from the resulting pollution loading.

Figure 1

Comparison of Per Capita Energy Use by Settlement Pattern in Canada



Data show demand for end use energy, which is why the total is less than in Fig A-1 which shows total primary energy

2. The Metropolitan Toronto profile is based on information prepared by Kevin Loughborough as part of Metro's participation in the International Council for Local Environmental Initiatives, and is summarized in the report mentioned in the previous note.

3. City of Ottawa data taken from Kai Millyard, A Preliminary Carbon Dioxide Inventory for the City of Ottawa, prepared for the city of Ottawa Dept. of Engineering and Works, February 1992.

4. The provincial and national energy statistics are taken from Torrie Smith's database, which is derived from the national energy balances in Statistics Canada Catalogue 57-003, Consumption of Purchased Fuels and Electricity.

5. See for example, Ralph D. Torrie, Cities and CO_2: Research Results and Policy Implications from the Urban CO_2 Reduction Project, prepared for the International Council for Local Environmental Initiatives, Municipal Leaders' Summit on Climate Change and the Urban Environment, United Nations Building, New York, January 1993.

Table 1

SELECTED CANADIAN ENERGY USE STATISTICS					
City/Region	Ottawa	City of Toronto	Metro Toronto excluding City of Toronto [2]	Ontario	Canada
POPULATION	306,826	597,126	1,536,333	9,402,000	25,909,000
FUELS AND ELECTRICITY: (PJ), Year	1990	1988 [1]	1988	1988	1988
GAS					
Residential	4.9	30.9	42.7	253.5	507.0
Commercial	7.7	13.5	31.7	152.3	373.5
Industrial	1.0	10.2	26.1	346.0	857.4
Transporation	0.0	0.2	0.2	0.5	2.3
TOTAL GAS	13.7	54.8	100.7	752.2	1,740.2
ELECTRICITY					
Residential	6.0	6.5	25.4	148.3	434.2
Commercial	9.2	22.4	18.5	139.6	371.8
Industrial	1.0	2.0	12.7	169.0	675.1
Transporation	0.0	1.0	0.2	1.2	2.9
TOTAL ELECTRICITY	16.3	32.0	56.8	458.2	1,484.1
OIL					
Residential	1.9	1.1	13.3	61.5	201.9
Commercial	0.8	1.4	8.8	69.8	275.2
Industrial	3.0	1.7	20.4	88.3	346.7
Transporation	18.2	29.7	130.8	609.3	1,702.9
TOTAL OIL	23.8	34.0	173.3	829.0	2,526.7
OTHER					
Residential	0.0	0.0	0.0	0.0	2.8
Commercial	0.0	2.7	0.0	2.7	3.6
Industrial	0.0	0.9	0.0	209.8	242.6
Transporation	0.0	0.0	0.0	0.0	0.0
TOTAL OTHER	0.0	3.6	0.0	212.6	249.1
ALL FUELS AND ELECTRICITY					
Residential	12.9	38.6	81.4	463.4	1,146.0
Commercial	17.7	40.0	59.0	364.4	1,024.2
Industrial	5.0	14.8	59.2	813.1	2,121.8
Transporation	18.2	30.9	131.2	611.0	1,708.1
TOTAL ENERGY - ALL FUELS	53.8	124.3	330.7	2,251.9	6,000.1
PER CAPITA FUELS AND ELECTRICITY					
Residential	**42**	**65**	**53**	**49**	**44**
Commercial	**58**	**67**	**38**	**39**	**40**
Industrial	**16**	**25**	**39**	**86**	**82**
Transporation	**59**	**52**	**85**	**65**	**66**
TOTAL	**175**	**208**	**215**	**240**	**232**
SECTOR SHARES					
Residential	**24%**	**31%**	**25%**	**21%**	**19%**
Commercial	**33%**	**32%**	**18%**	**16%**	**17%**
Industrial	**9%**	**12%**	**18%**	**36%**	**35%**
Transporation	**34%**	**25%**	**40%**	**27%**	**28%**
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**
OTHER INFORMATION					
Office Floor Space (10e6 m2)		6.78	3.70	38.20	92.50
Retail Floor Space (10e6 m2)		2.78	3.02	23.10	67.70
Per Capita Floor Areas (m2/cap)					
Office Floor Space	-	11	2	4	4
Retail Floor Space	-	5	2	2	3

Notes and References

[1] 1986 data for the industrial sector, see reference [3] below

[2] Metro Toronto data minus City of Toronto data

[3] Ottawa: Millyard, Kai - A Preliminary Carbon Dioxide Inventory for the City of Ottawa Feb 1992, prepared on behalf of Friends of the Earth Climate Change Program under contract to the City of Ottawa Department of Engineering and Works

[4] City of Toronto:
- Residential: City of Toronto Potential for Oil and Gas Conservation - Residential Sector, Marbek Resource Consultants, 1993
- Commercial: City of Toronto Potential for Oil and Gas Conservation - Commercial/Institutional Sector, Marbek Resource Consultants, 1993
- Industrial: Analysis of Industrial Fuel Use and Conservation Potential in the City of Toronto, Torrie Smith Associates/Kentek Ltd. (1986 data for oil and gas), December 1992
- Transportation: Transportation and Land Use, The City of Toronto and the Municipality of Metropolitan Toronto, VII of II, City of Toronto, March 1992, report for ICLEI workshop, Dade County, Florida

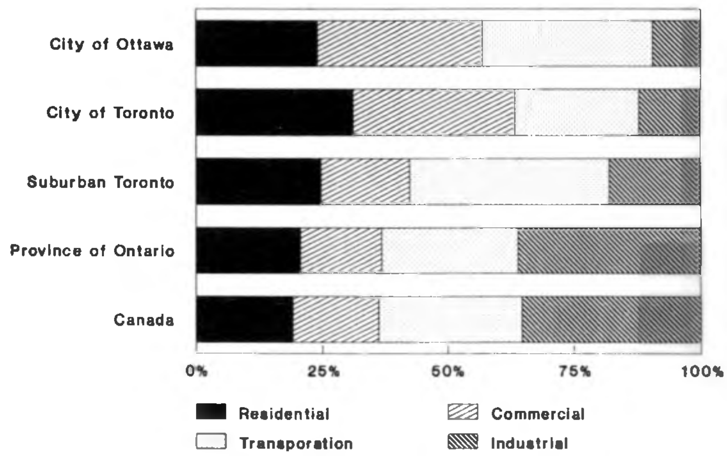
[5] Metro Toronto: Personal communication from Kevin Loughborough, City of Toronto Energy Efficiency Office.

[6] Ontario: Consumption of Purchased Fuel and Electricity, Statistics Canada, cat. no. 57-003

[7] Canada: Consumption of Purchased Fuel and Electricity, Statistics Canada, cat. no. 57-003

Figure 2

Variation in Sector Shares of Energy Use by Settlement Pattern in Canada



As illustrated in Figure 2, the breakdown of energy use by sector is different for cities than for the general population, with a greater share of energy use in cities accounted for by buildings and transportation and a smaller share for industrial production. The differences in the commercial sector are especially striking; in the urban cores of Ottawa and Toronto, the commercial/institutional sector accounts for a third of all energy use, twice as high as its share of provincial and national energy use. Cities are by their very nature centres of commerce and bureaucracy; the associated concentration of office and retail establishments often represents the largest target for urban energy management for environmental improvement.

On a per capita basis, transportation energy use tends to be lower than average in dense urban settlements (eg. City of Ottawa, City of Toronto) but higher than average in suburban developments (eg. Suburban Metropolitan Toronto). Transportation energy use is nevertheless a very large component of urban energy demand, and one of the most environmentally problematic. The automobile dependence of suburban settlement patterns contributes to especially high transportation energy use in these communities, a finding which has been confirmed in international comparisons.

Industry has a relatively low share of energy use in the cities studied. Canadian industrial energy use is concentrated in a small number of energy intensive industries related to primary resource extraction and processing (pulp & paper, primary metals, industrial chemicals, mining) and these industries do not have a significant presence in the cities profiled here, or in most Canadian cities. Industry's share of total energy use is particularly low for the urban cores in which economic activity is dominated by commercial and institutional services. There is a slightly higher share for suburban areas; for example, industry is a significant contributor to the economy of Metro Toronto, but it tends to be secondary manufacturing activity and food processing industries in which energy intensities are not very much higher than in the service sector.

The Need for Improved Urban Energy Data

The development of effective municipal energy plans will require a much better database of urban energy use patterns than currently exists in Canada. In fact, this is a widespread problem facing municipal energy managers in North America and Europe: the information base upon which to design policy and programmes is ill-equipped to support analysis at the urban level.

The techniques of energy demand analysis can be successfully applied to building up a profile of urban energy use by fuel and by end-use for the residential, commercial, institutional and industrial sectors[6]. The municipal property tax records usually contain enough information to create an adequate profile of the building stock. If electric utilities and oil and gas distributors cooperate in providing disaggregated information on fuel and electricity sales by region and type of customer, this can be used to calibrate end-use models of energy demand. From this point the conventional energy demand and conservation literature can be used to develop estimates of the potential impact various engineering and urban design measures could have on total fuel and electricity use and related pollution.

The transportation sector presents a more difficult challenge. Even where vehicle fuel sales data are available for a municipality, they will only correlate with transportation fuel use to the extent that fuel purchased in the municipality but burned elsewhere and fuel burned in the municipality but purchased elsewhere are either insignificant or approximately equal. There is therefore no reliable measurement of the total amount of transportation fuel burned in municipalities in Canada.

6. For example, see the series of studies cited above in Note 1, carried out for the City of Toronto by Marbek Resource Consultants and Torrie Smith Associates.

Such estimates will have to be built "from the bottom up" by combining information about traffic volumes, speeds and driving cycles with information about the characteristics of the vehicles on the road (weight, engine displacement, cold start characteristics, etc.). Vehicle registration databases contain much of the necessary information about vehicle characteristics, but additional research is needed to establish the manner in which vehicle energy use and emissions varies under different driving conditions and ambient weather conditions. Traffic data are voluminous in most cities and the larger cities operate transportation demand models to assist in infrastructure planning, but for the application to energy demand and emissions analysis there will be significant changes required to both the data being collected and the models being used. In particular, in energy and emissions analysis, the emphasis shifts from the peak period to the 24-hour period, and it becomes important to characterize total trip times and driving cycles (number of stops, accelerations, decelerations, etc.). Finally, analysis of energy and emissions reduction measures will require improvements in the available data and models with regard to trip making (number of vehicle trips, mode, length, etc.) and how it is affected by land use, urban form and spatial structure, and demographics.[7]

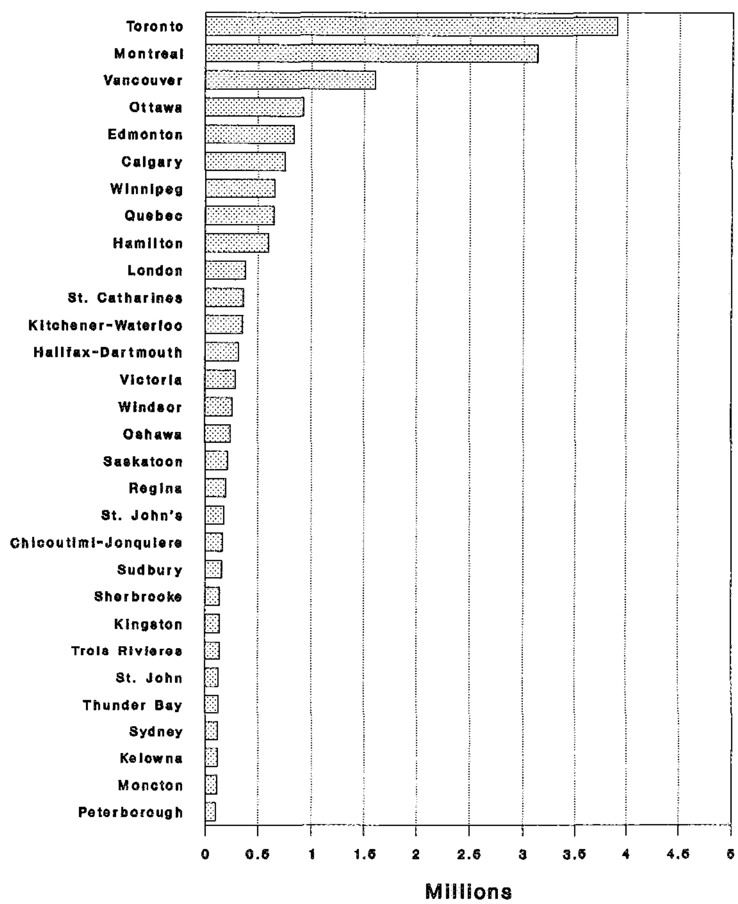
7. See Eric J. MIller and Mazen I. Hasssounah, Quantitative Analysis of Urban Transportation Energy Use and Emissions, University of Toronto, 1993; available from Joint Program in Transportation, University of Toronto, 42 St. George Street, Toronto, Ontario, M5S 2E4. Also, William Anderson, Pavlos Kanarogou and Eric Miller, Urban Form, Energy and the Environment: A Review of Issues, Evidence and Analytical Approaches, McMaster Institute for Energy Studies, McMaster University, Hamilton, Ontario, Canada, April 1993; IBI Group, Urban Travel and Sustainable Development -- The Canadian Experience, prepared for Canada Mortgage and Housing Corporation, Ottawa, Canada, February 1993; IBI Group, Initiatives to Limit Transportation Energy Consumption and Emissions in Canadian Cities, prepared for Natural Resources Canada, Ottawa, September 1993; IBI Group, "Environmental Review of the Regional Official Plan -- Background Paper on Environment, Transportation and Land Use", prepared for the Regional Municipality of Ottawa-Carleton, February 1993. For a concise summary of the emerging agenda for transportation data and modelling, see U.S. Department of Transportation, U.S. Environmental Protection Agency, and U.S. Department of Energy, "Travel Model Improvement Program", information available from Gordon Shunk, Texas Transportation Institute, tel (817)-277-5503, fax (817)-277-5439.

2.2 Urban Settlement Patterns in Canada

Table 2 lists the largest urban settlements in Canada and the populations of the thirty largest cities are illustrated in Figure 3. Table 3 illustrates the distribution of the urban population among cities of different sizes, by province, and Figure 4 illustrates the distribution of the Canadian population by rural and different sizes of urban settlements.

Figure 3

Population of 30 Largest Canadian Cities



Census of Canada, 1991

While 77% of the country's population is considered urban using the most general definition (at least 1000 people living with a density of at least 400 persons per square kilometre), only 62% of the population live in cities with populations greater than 100,000 and only 48% live in cities with populations greater than 500,000.

The distribution of population density also varies regionally in Canada. Consistent with its economic history, much of Canada has developed on the basis of primary resource extraction and processing (mining, forestry, pulp and paper, wheat and agriculture, fishing), economies in which urban centres first developed as centres of trade, commerce and services for the hinterland resource economy. Hence in the prairie provinces (Alberta, Saskatchewan and Manitoba) and the Atlantic region (New

Table 2

URBAN POPULATION OF CANADA IN 1991			
City	Province	Population [1]	Percent of Canada
Toronto	Ontario	3,893,046	14.3%
Montreal	Quebec	3,127,242	11.5%
Vancouver	British Columbia	1,602,502	5.9%
Ottawa	Ontario	920,857	3.4%
Edmonton	Alberta	839,924	3.1%
Calgary	Alberta	754,033	2.8%
Winnipeg	Manitoba	652,354	2.4%
Quebec	Quebec	645,550	2.4%
Hamilton	Ontario	599,760	2.2%
London	Ontario	381,522	1.4%
St. Catharines	Ontario	364,552	1.3%
Kitchener-Waterloo	Ontario	356,521	1.3%
Halifax-Dartmouth	Nova Scotia	320,501	1.2%
Victoria	British Columbia	287,897	1.1%
Windsor	Ontario	262,075	1.0%
Oshawa	Ontario	240,104	0.9%
Saskatoon	Saskatchewan	210,024	0.8%
Regina	Saskatchewan	191,062	0.7%
St. John's	Newfoundland	171,859	0.6%
Chicoutimi-Jonquiere	Quebec	160,928	0.6%
Sudbury	Ontario	157,613	0.6%
Sherbrooke	Quebec	139,194	0.5%
Kingston	Ontario	136,405	0.5%
Trois Rivieres	Quebec	136,303	0.5%
St. John	New Brunswick	124,981	0.5%
Thunder Bay	Ontario	124,427	0.5%
Sydney	Nova Scotia	116,095	0.4%
Kelowna	British Columbia	111,850	0.4%
Moncton	New Brunswick	106,505	0.4%
Peterborough	Ontario	98,060	0.4%
Guelph	Ontario	97,210	0.4%
Brantford	Ontario	97,105	0.4%
Belleville	Ontario	94,995	0.3%
Barrie	Ontario	92,165	0.3%
Sarnia	Ontario	87,870	0.3%
Sault Ste. Marie	Ontario	85,010	0.3%
Fredericton	New Brunswick	71,865	0.3%
Prince George	British Columbia	69,650	0.3%
St Jean-sur-Richelieu	Quebec	68,380	0.3%
Kamloops	British Columbia	67,855	0.2%
North Bay	Ontario	63,280	0.2%
Shawinigan	Quebec	61,670	0.2%
Chilliwack	British Columbia	60,255	0.2%
Drummondville	Quebec	60,090	0.2%
Charlottetown	PEI	57,475	0.2%
Rest of Canada	All Provinces	8,927,479	32.7%
CANADA	Canada	27,296,100	100.0%

Source: Statistics Canada 1991 Census

[1] The population figures here are actually for Census Metropolitan Areas (CMA's) in the case of cities with more than 100,000 and for Census Agglomerations for cities less than 100,000. As such, the figures include the population of the area around the urban core itself but which is considered to be socially and economically integrated with the urban core.

Table 3

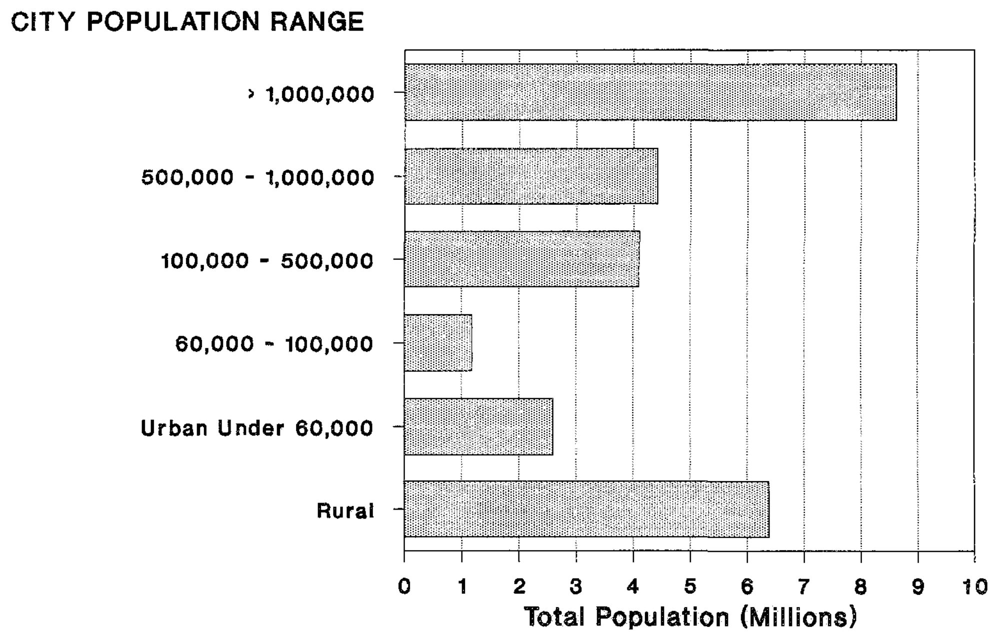
URBAN POPULATION OF CANADA, BY PROVINCE AND CITY SIZE
(DATA BASED ON 1991 CENSUS OF CANADA)

PROVINCE	TOTAL POPULATION	Urban Population [1]		Cities with population > 1,000,000		Cities with population 500,000 - 1,000,000		Cities with population 100,000 - 500,000		Cities with population > 100,000	
		Population	% of Pop.	Population	% of Pop.	Population	% of Pop.	Population	% of Pop.	Population	% of Pop.
British Columbia	3,282,100	2,640,100	80%	1,602,502	49%	0	0%	399,747	12%	2,002,249	61%
Alberta	2,545,600	2,030,900	80%	0	0%	1,593,957	63%	0	0%	1,593,957	63%
Saskatchewan	988,900	623,400	63%	0	0%	0	0%	401,086	41%	401,086	41%
Manitoba	1,091,900	787,200	72%	0	0%	652,354	60%	0	0%	652,354	60%
Ontario	10,084,900	8,253,800	82%	3,893,046	39%	1,520,617	15%	2,023,219	20%	7,436,882	74%
Quebec	6,896,000	5,351,200	78%	3,127,242	45%	645,550	9%	436,425	6%	4,209,217	61%
New Brunswick	723,900	345,200	48%	0	0%	0	0%	231,486	32%	231,486	32%
Prince Edward Island	129,800	51,800	40%	0	0%	0	0%	0	0%	0	0%
Nova Scotia	899,900	481,500	54%	0	0%	0	0%	436,596	49%	436,596	49%
Newfoundland	568,500	304,500	54%	0	0%	0	0%	0	0%	0	0%
Yukon/Northwest Territories	85,400	37,500	44%	0	0%	0	0%	0	0%	0	0%
CANADA	27,296,900	20,907,100	77%	8,622,790	32%	4,412,478	16%	3,928,559	14%	16,963,827	62%

[1] Using Statistics Canada's most general definition of urban: at least 1000 people with a density of at least 400 persons per square kilometre

Figure 4

Distribution of Population in Canada in 1991, by City Size



Source: Government of Canada Census
Total National Population: 27.3 million

Brunswick, Nova Scotia, Prince Edward Island, Newfoundland) there are typically one or two relatively large cities, and then a large gap in community size to the next group of much smaller local centres.

There is a more complete distribution of city size in Ontario, Quebec and British Columbia, each of which has one of the three largest metropolitan areas in the country: Toronto (3.9 million), Montreal (3.1 million) and Vancouver (1.6 million), together comprising a third of Canada's population. Ontario is the most urbanized of Canada's provinces; it has the largest metropolitan area (Toronto), the largest percentage of urban dwellers of any Canadian province (82%) and the most pervasive pattern of urbanization, with the largest number of cities in all the intermediate and small size categories.

2.3 The Role of Municipal Government in Canada

To understand both the historic record and the future possibilities for urban energy management in Canada, it is useful to review the relative position of urban governments in the Canadian constitutional system. Canadian cities do not have the type of comprehensive urban government found in some European countries, in which local governments have broad powers to make policies covering a wide range of social, economic and environmental issues affecting urban life. Only the federal and the provincial levels of government are recognized in the Canadian constitution, and municipal governments derive both their existence and their jurisdictional authority from their legally superior provincial counterparts, and their boundaries are changed frequently in response to spreading urbanization. Most provinces utilize some form of multi-tiered structure in which regional governments are established to coordinate the activities and common concerns of a group of municipal governments that are part of a contiguous metropolitan area, and power and responsibility is shared between these regional governments and their individual municipal members.

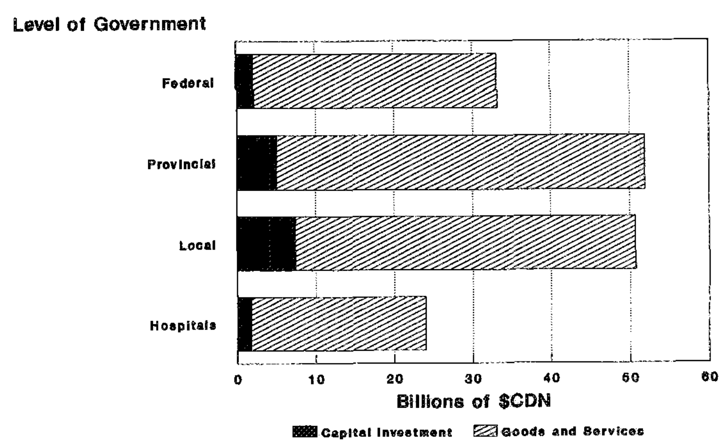
Although there are many matters of federal responsibility which have direct and far-reaching impacts on Canadian urban life -- economic and fiscal policy, trade, immigration, airports and sea ports, national defence, housing, etc., and while the federal government remains the single largest landowner in urban Canada, it is the provincial governments which have the most pervasive influence on urban life.

From the perspective of urban energy use and management, provincial governments have the major share of responsibility. They are constitutionally responsible for municipal affairs and they also control education, social services, health care, and most of the highways. In most of Canada, the supply and distribution of electricity is controlled by provincially owned utilities with *de facto* monopolies. Energy and environment are areas in which there is shared responsibility between federal and provincial governments, but on matters of most direct relevance to municipal energy management, the provinces occupy the key areas: regulation of energy commodity markets and prices, the setting of air and water pollution regulations, waste management, land use planning, building codes, and the building and maintenance of the water supply and sewage treatment infrastructures. In addition, there are many municipally-based services, such as policing, schools, libraries, local electricity and water supply, which are controlled by special purpose boards and commissions established by the provincial government and over which the municipal government has little if any direct control.

In general, the primary focus of local government in Canada is land use and the built environment,[8] and municipal governments in Canada raise about half their revenue from indirect taxes, usually in the form of property taxes, with most of the balance coming in the form of transfers from the provincial governments. In most of Canada, the provincial governments have delegated responsibility for land use planning to municipal governments. Notwithstanding the limits to their constitutional authority, local governments in Canada are a very large and important branch of government, accounting for a third of total government spending on goods and services (net of transfers, debt servicing, and capital investment). Figure 5 illustrates the sum of goods and services expenditures and fixed capital investment for the different levels of government in 1992, and the dominance of the provincial/municipal axis is apparent. With their focus on infrastructure provision, municipal governments account for the largest share of government fixed capital investment in Canada.

Figure 5

Current Expenditures on Goods & Services and Fixed Capital Investment by Level of Government in Canada, 1992



Source: Canadian Economic Observer, 1993

Considering that much of the provincial fixed capital investment and expenditures on goods and services is tied to provincial participation in urban infrastructure projects, the government prevalence in the municipal sector looms large.

8. For a more detailed discussion see Andrew Sancton, "The Municipal Role in the Governance of Canadian Cities", in Trudi Bunting and Pierre Filion, editors, Canadian Cities in Transition, Oxford University Press, Toronto, 1991, pp. 462-486.

3. URBAN ENERGY MANAGEMENT FOR ENVIRONMENTAL IMPROVEMENT IN CANADA

3.1 Introduction

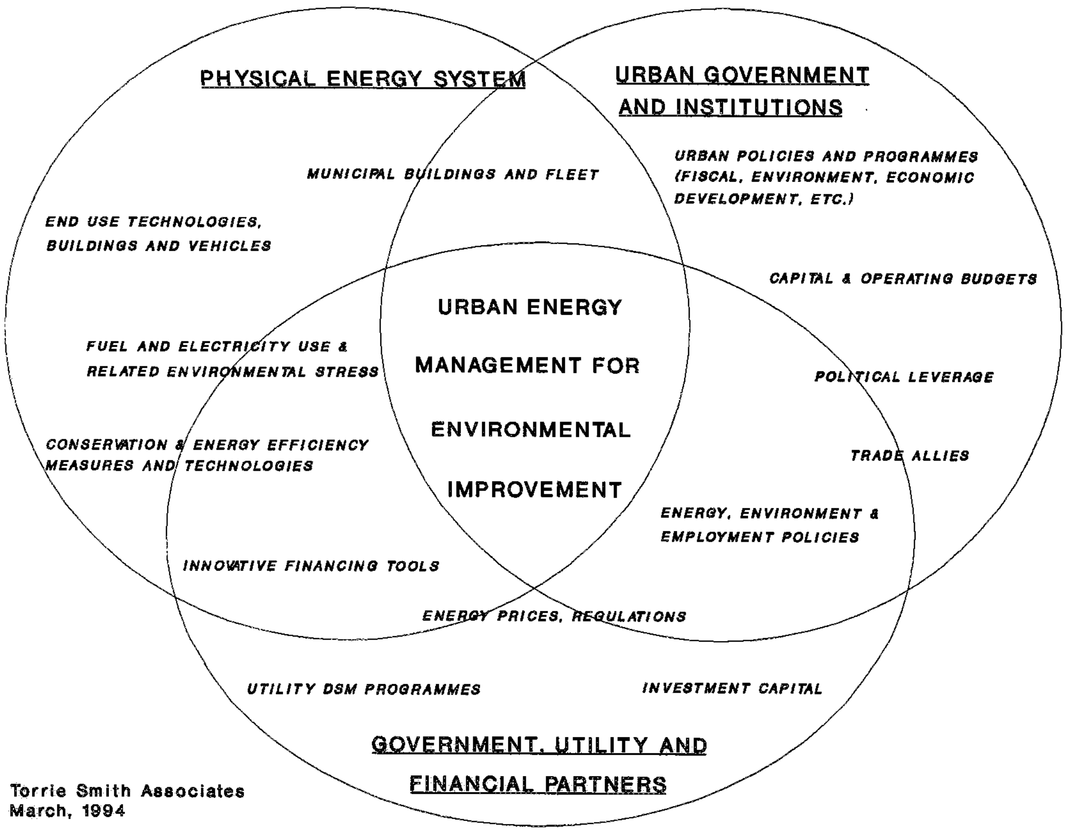
In Canada, urban energy management for environmental improvement requires proactive commitment and initiative from local governments, and a growing number of Canadian cities are making such commitments. There are as many reasons for this trend as there are benefits from energy management, but invariably the successful initiatives are the ones in which urban governments form partnerships with and obtain the active cooperation of the citizenry, the business community, and other levels of government.

Figure 6 illustrates, in the form of Venn diagram, a framework for thinking about urban energy management for environmental improvement. In this framework, urban energy management for environmental improvement is located in the intersection of three overlapping domains, each of which is a necessary component if local governments are to become significant players in the energy dimension of the transition to sustainable development. It is a framework which emphasizes the multiple benefits and synergistic nature of urban energy management as an opportunity for achieving other objectives held by the local government and for benefitting from the partnerships that can be formed with other governments and businesses with an interest in promoting energy management.

- First, there needs to be a quantitative and comprehensive description of the ***physical energy system*** itself. The term "physical energy system" refers to the physical quantities, qualities and patterns of fuels and electricity use within cities, the associated conversion and end use technologies, the related built environment and infrastructure, and the associated emissions of carbon dioxide and other pollutants. This is the system that energy management for environmental improvement seeks to change, and priorities cannot be established without knowing how much energy is used for what purposes and with which technologies; scenarios of the future level and pattern of these energy use patterns; and the costs and benefits of measures and technologies that are available for reducing the quantity and/or the environmental impact of the fuels and electricity used. In the case of urban energy management, such baseline database development and analysis includes

Figure 6

Urban Energy Management for Environmental Improvement



understanding the relation between energy use (and related environmental impacts) and such factors as urban form, density, settlement and land use patterns.

- The second domain represented in Figure 6 represents ***urban government and institutions***. To develop and implement effective energy management strategies, urban governments must understand and make the most of their political leverage by designing programmes that have the involvement and support of their citizenry. This generally means designing programmes that take advantage of the synergies between energy management for environmental improvement and the many other benefits to the local community. Proposals for energy management strategies that require large investments will often necessitate innovative financing techniques that avoid the need for local government borrowing. In the longer term, local governments must identify and work toward the changes in their jurisdiction and authority that will be necessary for them to be effective agents for sustainable development of their communities.

- The third component in the framework represented in Figure 6 is comprised of the various ***government, utility and financial partners,*** which, for their own reasons have an interest in urban energy management; partnerships are a key to the success of urban energy management. Senior levels of government need the active cooperation of municipalities in achieving their energy and environment policies, and funding can often be obtained for energy management initiatives when they can be shown to achieve economic, employment and social objectives of the senior governments. Utilities promoting demand side management (DSM) will provide technical and financial resources in return for municipal partnership in marketing their DSM programmes. And the financial sector is developing special products to help finance and underwrite energy management in ways that reduce the risk to the municipality and the energy end user, lower the "rate of return threshold" for the investments, and attract third party investors in ways which avoid the need for municipal financing of the energy management measures.

Finally, energy management for environmental improvement will be most successful if developed in the context of the full range of effects that human activity in urban settlements has on local, regional and global ecosystems. While it is generally true that conservation and efficiency and a shift to renewable energy are good for the environment and should be pursued, unless "urban energy management" priorities are set in the context of some overarching understanding of the impact on ecosystem health of all human activity in the urban community, there is no way to judge how important energy management initiatives might be relative to, for example, water conservation or recycling initiatives. Successful urban energy management policies and programmes will be those which are designed and executed in the context of an integrated approach to the "greening" of the city

Urban energy management for environmental improvement takes place in the intersecting area of Figure 6 where cities can identify policies and programmes that can be executed within the Canadian urban institutional and policy framework (modified if necessary and possible) that will affect the physical energy system in ways that will enhance ecosystem health.

3.2 Overview of Urban Energy Management in Canada

In preparing this report on urban energy management for environmental improvement in Canada, an informal telephone survey was conducted of the largest cities, as well as a number of smaller centres in which interesting initiatives are being taken. Information gathered in this way was supplemented by in-house knowledge of urban energy management activities in Canada and reference to similar surveys undertaken recently by the International Council for Local Environmental Initiatives[9] and the Intergovernmental Committee on Urban and Regional Research.[10,11] Sustainable urban transportation is the subject of a separate report[12] and; this paper focuses therefore on non-transportation related energy use. The survey revealed that urban energy management is practiced at three stages or levels in Canada:

Level One: In-House Energy Management

Level One consists of efforts to reduce the fuel and electricity use of the municipality's own operations, including its buildings, facilities and vehicle fleet. This is by far the most prevalent form of urban energy management in Canada. It is almost always motivated by the related financial savings in operations, and is under the direct control of municipal professional staff. Typically, measures to reduce fuel and electricity consumption are undertaken by the departments responsible for operating the facilities. With few exceptions, simple payback criteria are used to

9. Tanya Imola, "Survey of Municipal Actions on Climate Change in Canada: Summary and Recommendations", International Council for Local Environmental Initiatives with the Federation of Canadian Municipalities, for Environment Canada, September 1993.

10. Virginia W. MacLaren, Sustainable Urban Development in Canada: From Concept to Practice, ICURR Press, 1992; a three volume report prepared for the Intergovernmental Committee on Urban and Regional Research, Suite 301, 150 Eglinton Avenue east, Toronto, Ontario, Canada M4P 1E8; Tel: (416)-973-5629, Fax: (416)973-1375.

11. Paule Ouellet, Environmental Policy Review of 15 Canadian Municipalities, ICURR Press, 1993; a two volume report prepared for the Intergovernmental Committee on Urban and Regional Research, Suite 301, 150 Eglinton Avenue east, Toronto, Ontario, Canada M4P 1E8; Tel: (416)-973-5629, Fax: (416)973-1375.

12. IBI Group, "Urban Travel and Sustainable Development -- The Canadian Experience", prepared for Canada Mortgage and Housing Corporation, February 1993.

screen candidate measures and relatively fast paybacks are demanded (usually less than three years, rarely more than five).

Most municipalities engage in some Level One energy management; it is not really energy management *for* environmental improvement, although those cities which have committed to reducing their own CO_2 emissions are now pursuing internal energy conservation targeted toward their CO_2 reduction goals. The level of effort and financial resources devoted to Level One energy management varies over a wide range. At the very least, it consists of an informal system of factoring in energy costs when city buildings are renovated or repaired. A more progressive approach to managing energy at this level consists of formal administrative structures that are designed specifically to save money by reducing energy consumption. This can include creating an energy management office and/or energy management staff position(s); formalizing specific policies, goals and programmes aimed at reducing energy consumption within the city bureaucracy and city-owned and managed properties; and implementing an accounting system to provide detailed tracking of city energy use and the savings realized.

An important benefit from Level One energy management activity is the hands-on experience it provides in the implementation of energy management projects. Many of the same financial, institutional and technical barriers that are encountered in community-wide urban energy management programmes will also be encountered in the design and delivery of Level One energy management, and the city's experience in solving these problems will prove invaluable when and if the city proceeds to more broad-based energy management programmes in the community-at-large.

Level Two -- Urban Energy Management

The second level of urban energy management represents an intermediate stage between in-house conservation programmes and strategic urban energy management for environmental improvement. In Level Two energy management, programmes are extended to the community-at-large, but environmental improvement is not a primary rationale for the programmes or sometimes even a consideration. Programmes can be mounted in partnership with utilities seeking to achieve demand side management targets in the urban market, or with other levels of government to achieve policy goals related to energy security, employment, or economic development. Actions at this level can include setting up energy information centres, energy efficiency programmes in conjunction with the local utility; and the development of district heating and cogeneration systems. In the late 1970's and early 1980's, when energy security was high on the policy agenda of federal and provincial governments, Canadian municipalities were encouraged and given support to mount community energy conservation and renewable energy programmes, and much of the "corporate memory" that resides in Canadian communities with respect to community energy management dates to these Level Two type initiatives. In the context of urban energy management for environmental improvement, Level Two initiatives are important for two reasons: first, they still result in environmental improvement, even if that is not their purpose and second, they contribute to the development of techniques and experience in the delivery of community-wide energy management programmes.

Level Three -- Urban Energy Management for Environmental Improvement

The third and most advanced stage of urban energy management involves the integration of urban energy management into strategies for environmentally sustainable community development. At this stage, energy management programmes are broadly based in the community and comprehensive in their coverage of sectors and end uses. They are driven by environmentally related targets rather than economic targets; for example, to achieve a certain minimum level of air quality in the community or to reduce CO_2 emissions by a targeted amount. As well as various initiatives to promote energy efficiency and renewable energy in the infrastructure, buildings, and vehicles throughout the community, considerations of energy and environmental sustainability are integrated into urban form and land use planning. The multiple benefits of energy management (job creation, community economic development, air quality, etc.) are stressed in the marketing of Level Three initiatives, and programme delivery is coordinated with related programmes for waste reduction and recycling, water management and sustainable urban transportation. Level Three energy management is taken on for strategic purposes, and is often part of a long range plan for community social and economic development.

3.3 Exemplary Canadian Experience

This section describes a number of examples of urban energy practice in Canada. Although information on energy management practices was gathered from every region in Canada, examples are included here that are especially illustrative of innovative approaches to achieving the multiple benefits and overcoming the barriers to urban energy management for environmental improvement.

3.3.1 Energy Management in the City of Ottawa

For more than ten years, the City of Ottawa has had an engineer responsible for an in-house energy conservation programme with an annual capital budget of $200,000. This money is allocated to the top priority projects each year and most of the projects implemented have had simple paybacks of three to five years.[13]

A recent review of the history and future potential of conservation in the city's recreation facilities (hockey arenas, swimming pools, community centres) indicated that cumulative energy management expenditures on these buildings between 1986 and 1992 of $466,500 were yielding annual savings of $150,000, reflecting an average simple payback of 3.1 years.[14] The total fuel and electricity bill for this group of buildings in 1992 was $1.45 million. The measures have included lighting retrofits, gas to oil boiler conversions, heat recovery systems, ceiling and roof insulation, computerized energy management systems, installation of dehumidifiers in pool buildings, and various modifications to ice making equipment.

The Ottawa programme, which is one of the more well established and successful of its kind, illustrates some of the limitations of this type of Level One energy management activity. There is a certain amount of money available each year for energy management initiatives and it quite naturally is spent in ways that give the highest returns. The resulting paybacks are relatively fast and the energy

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13. The Ottawa energy conservation programme is directed by Mr. Bruce Hoskin, Energy Management Coordinator, Building Operations and Maintenance, City of Ottawa. Tel: (613)-564-1914.

14. Torrie Smith Associates, "City of Ottawa Case Study", presentation to Ontario Municipal Energy Collaborative, International Council for Local Environmental Initiatives, December 1993.

management activity stops short of what could be accomplished with an approach that regarded energy management expenditures as strategic investments. For example, in the recreation buildings included in the case study described in the previous paragraph, it was estimated that if $2.5-3.0 million had been invested (instead of the actual $466,500) over the same period that the fuel and electricity bill could have been brought down by about $600,000 or about 37%. This would have required using measures with paybacks in the 5-10 year range (still representing an average return on investment of more than 10%).

The generic issue illustrated here is that when energy management initiatives are internally financed, they are typically evaluated according to simple payback criteria that equate to internal rates of return of 20%-40% and even higher. In the context of energy management for environmental improvement, much more significant environmental gains can be achieved if energy efficiency expenditures are treated as investments that go ahead if they offer a competitive return with alternative uses of the money. In the Ottawa case study cited above, for example, only the more aggressive package of measures (5-10 year paybacks) results in CO_2 emission reductions which add up to the 20% and higher cuts being targeted by environmental policies.

3.3.2 *Regina: In-House Urban Energy Management for Environment Improvement*

Regina has one of the most advanced (corporate) municipal energy management systems in Canada.[15] This includes an energy efficiency office, full time staff, a comprehensive energy accounting system, a regular newsletter, "independent" funding and a variety of programmes. A key to the success of the Regina in-house conservation programme is the production of an annual report which summarizes energy costs by department and function, capital cost and estimated annual savings for each conservation project, and describes other activities and initiatives of the energy management programme (eg. the newsletter, review of cogeneration potential, natural gas usage, etc.). The report is delivered to city council

15. Contact: Mr. Randy Strelioff, Energy Management Coordinator, Administrative Services Branch, City of Regina, P.O. Box 1790, Regina, Saskatchewan, S4P 3C8; Tel: (306) 777-7514, Fax: (306)-777-7478.

and serves as a reminder of the cost effectiveness of the city's energy management programme. A computerised energy accounting system is used to track energy consumption, costs and savings for the variety of fuels used by the corporation.

The measures undertaken as part of Regina's internal energy management programme have the fast paybacks typical of municipal Level One activities. In 1991, for example, the Annual Report of the Energy Management Programme itemizes ten projects undertaken that year at a total cost of $66,400 with a projected annual savings of $45,000, reflecting a simple payback average of about 18 months.

To overcome the problem of the quick payback demanded by cash-poor line departments for energy management measures, in 1990 the City of Regina established the "Special Initiative Investment Programme", a model innovation that should be of interest to other municipalities and organizations developing energy management strategies. The Special Initiative Investment Programme (SIIP) is essentially an internal revolving fund (initially allocated $250,000) from which city departments may borrow money for energy efficiency measures. The money is then repaid, with interest, from the stream of savings generated by the measure. Initiatives financed by the fund must be able to repay the fund at rates equivalent to what the money could have earned if invested in the market place, but this is a much more liberal criterion for energy efficiency investments than the 50%-plus rate of return represented by an 18 month simple payback!

One of the aspects of the Regina energy management programme that sets it apart from most other Level One initiatives is its strategic approach and the extent to which the multiple benefits of energy conservation are explicitly recognized in both the mission and the marketing of the programme. In particular, the environmental benefits of the energy management activities are considered an important rationale for the expenditures. In 1991, the City Council adopted a resolution setting targets for CO_2 emission reductions of 20% from 1988 levels attributable to all direct activities within the geographical jurisdiction of the City of Regina, and a separate target of a 20% reduction from 1998 levels *by 1998* for the emissions attributable to all direct operations of the City of Regina administration, boards and commissions.

In 1991, the City produced a corporate plan to reduce CO_2 emissions within the operations of the municipal government. The cost of the measures was identified to be $8.3 million, and over all is expected to be cost effective. The plan calls for energy conservation measures, employee education and awareness, and the development of parkland as measures for reaching the target.

3.3.3 *District Heating and Cooling in Canada*

From the outset, the OECD project has identified community-based district heating systems as a potentially important means for municipalities to practice urban energy management for environmental improvement. There is certainly no question that in those societies where district heating plays a major role in the energy system, and where the planning and construction of such systems is integrated into the planning and building of the urban infrastructure, it makes a large difference in the overall energy intensity of urban settlements. A recent comparison of the energy use patterns of a group of Canadian and North American cities found that district heating was second in importance only to the low transportation energy intensities in explaining the relatively lower energy intensities of European cities as compared with Canadian and American cities.[16]

In Canada, district heating is often employed on large institutional campuses (eg. universities, military bases) but it makes a relatively small contribution to total energy use. Also, the electric power system in Canada has developed according to a centralized model in which most electricity is generated in large central stations optimized for electricity production, and there has not yet been any significant development of combined heat and power (CHP) facilities. There are steam-based district heating plants providing space heating to buildings in the city cores in Toronto, Winnipeg, Vancouver and Montreal; hot water based systems are located in Ottawa and Charlottetown.[17]

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16. Ralph Torrie, Cities and CO_2: Research Results and Policy Implications from the Urban CO_2 Reduction Project, prepared for the International Council for Local Environmental Initiatives, Municipal Leaders' Summit on Climate Change and the Urban Environment, New York, January 1993.

17. Morgan Macrae, Realizing the Benefits of Community Integrated Energy Systems, Study No. 45, Canadian Energy Research Institute, 3512 - 33rd Street N.W., Calgary, Alberta, Canada T2L 2A6, June 1992.

There has been a recent resurgence in interest in district heating and CHP facilities in Canada, spurred partly by concern over energy-related environmental impacts of fuel combustion in cities. As the European experience has shown, the widespread application of district heating requires that its planning and development be integrated with the planning and development of both the urban infrastructure and the power supply system.

One interesting proposal in the City of Toronto entails using cold water from Lake Ontario to provide cooling for buildings in downtown Toronto. The plan, called Deep Lake Water Cooling (DLWC), consists of extracting water from Lake Ontario at a depth greater than 80 metres and pumping it through a piping network that could serve up to 80% of the buildings in the downtown core[18]. Extensive pre-engineering and feasibility analyses have been conducted and the concept is undergoing further assessment; the environmental benefits of CFC-free cooling are a major factor in the evaluation of deep lake water cooling.[19]

3.3.4 *Espanola: Exploiting the Benefits of Utility Partnership*

Espanola was selected by Ontario Hydro as a testing ground for a community-based approach toward achieving comprehensive energy demand management. Espanola is a small paper mill town in northern Ontario with a population of 5,400 and a "retrofitable" stock of 2,300 buildings (homes and businesses). The project, entitled "Espanola Power Savers Project" is of interest because of the very high penetration rates of energy management measures and because of its demonstration of the synergies that can be achieved through partnerships between communities and

18. Contact: Nicholas Vardin, Commissioner of Public Works and the Environment, City of Toronto, City Hall, Toronto, Ontario, Canada, M5H 2N2, tel (416)-392-7763, fax (416)-392-0816.

19 For a fuller account of this innovative proposal, see Canadian Urban Institute, "Cooling Buildings in Downtown Toronto", Final Report of the Deep Lake Water Cooling Investigation Group, February 1993. Available from Canadian Urban Institute, 2nd Floor, West Tower, City Hall, Toronto, Ontario, Canada M5H 2N1, Tel. (416) 392-0082, Fax. (416) 397-0276.

utilities.[20] Although the project was delivered by the provincial electric utility, the key to its success was the input, feedback and "door opening" ability of the *Community Advisory Committee.* The committee consisted of 30 members of the community representing a cross-section of interests ranging from seniors groups to the Chamber of Commerce. The Committee established a goal of getting 80% of the community to participate in the power Savers Project, and eventually achieved an 87% participation rate due in part to the good communication between the Committee and the utility (Ontario Hydro) as well as the marketing ability of the Committee within the Community.

Comprehensive energy audits were offered to every business and household in the community, consisting of a detailed analysis of fuel and electricity consumption patterns and opportunities for savings. Of the 87% of homes and businesses that received an audit, 72% of the kWh value of the measures recommended for all homes have been accepted. The relatively high acceptance rate was due to level of incentives offered by the utility which were, on average, 65% of the cost of the retrofit. Over the two year implementation phase of the project, the utility contributed $4.2 million toward the energy management measures and the community share totalled $2.1 million. In addition, it is estimated that there was an additional $600,000 invested by the community in measures directly related to the retrofit activity but which were not eligible for the utility incentives.

A total of about 8,000,000 kW.h per year in savings have been attributed to the programme, reducing the collective electricity bill in the community by nearly $600,000 per year. With an average simple payback in the range of ten years, the measures utilized in this programme go far beyond what most private decision-makers are willing to accept for energy efficiency investments. Ten year paybacks still represent a positive overall real rate of return in the range of 7%, well within the range that Canadian utilities have accepted when investing in energy supply.

A strategic partnership of this kind was not without barriers or resistance. The utility brought in an outside general contractor with special expertise in energy retrofitting, to manage the work. Initially, the local building trades did not welcome

20. Contact: Ross King, Manager of Community Programs, Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6. Tel: (416)-506-4844.

this move, and also worried that the comprehensiveness of the programme would result in there being very little renovation work to do in the community following the project. As the project developed, the local trades were heavily utilized in the installation of the measures and, in the process, learned valuable skills in the special techniques of energy efficient building and retrofitting that they were able to apply to other communities in the region.

The Espanola story highlights the potential for municipal partnerships with electric utilities. Canadian electrical utilities are pursuing demand side management (DSM) opportunities that help meet the utilities' financial, load management and environmental goals. From B.C. Hydro's Power Smart program to Hydro-Québec's Energy Efficiency Project, Canadian utilities are investing in electricity efficiency and there can be significant mutual benefit derived from utility/municipality partnerships.

3.3.5 *Green Communities Initiative: Provincial Leadership for Urban Energy Management*

Through its Green Industries Strategy, the Ontario government has recognized the economic development potential represented by the environmental imperative; part of this strategy is a programme called the *Green Communities Programme* which provides support for communities in the promotion of energy management and other initiatives for environmental improvement.[21] There is a strong element of community participation in the programme, which started out with three relatively small communities (Sarnia, Cornwall, Atikokan) and was subsequently expanded to include four more (Peterborough, Guelph, Elora, Port Hope). In the next phase, membership will be doubled, with a number of larger cities expressing interest in the programme (Ottawa, Toronto, Hamilton, London, Oshawa, Sault Ste. Marie, Thunder Bay, Markham, Elliott Lake, Collingwood, Barrie, Belleville).

21. Contact: Mr. Brad DeFoe, Coordinator, Communities Conservation Branch, Conservation and Prevention Division, Ontario Ministry of Environment and Energy, 135 St. Clair Avenue West, Suite 100, Toronto, Ontario, Canada M4V 1P5. Tel: (416)-327-1478; Fax: (416)-327-1514.

The objective of the programme is for the community to achieve energy efficiency goals through their own initiative; with guidance, training and financial assistance provided by the provincial government. A community's membership in the programme is often part of a larger community strategy for promotion of sustainable community development, and a variety of approaches have been supported through the programme.

For example, in Guelph, Ontario, a strategy for an environmentally sustainable community has been developed through the cooperation of a number of public and private sector, community-based organizations, including Guelph Ontario Public Interest Research Group (GOPIRG), the University of Guelph, the City of Guelph, Guelph Hydro, Union Gas, Canada Trust, the W.C. Wood Company (appliance manufacturers located in Guelph). The initiative, called Guelph 2000, originated with the Guelph Round Table on Environment and Economy and is now supported by the Green Industry and Green Community programmes of the provincial government.[22]

Peterborough, another "green community", provides an example of the type of grass roots community involvement that can lead to significant reductions in total community energy consumption with a minimum of bureaucracy and paper work.[23] Energy management is one of the activities promoted by "Peterborough Green Up", a community project with financial support from the Ontario Ministry of Environment and Energy, the Peterborough Utilities Commission, Consumers Gas, and others. The organization produces and disseminates educational material, organizes and conducts workshops, and in general acts as a promoter of environmental initiatives by individual citizens and businesses. The two major energy efficiency activities of Peterborough Green-Up are the residential "Green Home Visit" programme and the "Green Commercial Visits" and "IC&I Audits" (IC&I: industrial, commercial and institutional). Since June 1993, over 1300 homes have received a "green home visit"; this is a comprehensive environmental assessment of a household conducted by two trained assessors. The homeowner is left with an extensive list of retrofit recommendations to improve the energy efficiency of the house. In addition, the

22. Contacts: Guelph 2000 Office, 90 Yarmouth Street, Guelph, Ontario, Canada N1H 4G3. Tel. (519)-823-0860, Fax. (519)-823-8777.

23. Contacts: David McLeod, Manager, Peterborough Green-Up, 209 Simcoe Street, Peterborough, Ontario, Canada K9H 2H6. Tel. (705)-745-3238, Fax. (705)-745-4413.

assessors install an energy efficiency package which includes low-flow showerheads, toilet dams, insulating pipe wrap and a water heater blanket. Similar assessments are offered to small and medium businesses through "green commercial visits". The more detailed "IC&I" audits are conducted on a fee-for-service basis and include recommendations for energy efficiency retrofit investments.

3.3.6 Ottawa's Task Force on the Atmosphere

Ottawa, which has had a successful in-house energy programme for over fifteen years is in the early stages of a much broader based programme for urban energy management. This new initiative is part of a fundamental reorientation of the city's planning principles and operational policies in which sustainable urban development is the ultimate objective.

In 1991, the City of Ottawa published a new official plan in which "the greening of the city" was established as the overriding goal. The Mission Statement for the plan is entitled "Sustainable Urban Development":[24]

> *City Council accepts that change is an on-going phenomenon in cities which must be managed within the parameters imposed by the overriding aim of preserving a lasting habitat for humanity and wildlife. It also recognizes that economic prosperity can provide us with the capability to support wise resource management, to meet social needs and to improve environmental quality. Therefore, City Council supports an approach to managing urban development which balances the rights of the individual and the needs of society with the need to conserve our natural resource base and enhance the natural environment, thereby promoting the health of Ottawa's inhabitants and communities.*

The plan explicitly recognizes the importance of land use and infrastructure, and therefore the importance of municipal government initiative, to the goal of sustainable development, and advocates an ecosystem management approach to urban government. As part of the Plan's implementation, in 1992 the City of Ottawa

24. City of Ottawa, A Vision for Ottawa, three volumes, City of Ottawa Official Plan, February 1991.

issued a detailed agenda for environmental conservation and management.[25] The strategy integrates energy management objectives in a larger environmental framework that also covers programmes and policies for dealing with air, waste, water, soils, open space, land use and other issues.

Specifically with regard to energy management for environmental improvement, the agenda includes the following goals:

- Reduce consumption of fossil fuels through the reduction of energy consumption at the local level (city-wide), in order to reduce the emissions of carbon dioxide into the atmosphere and in turn, affect a corresponding reduction in contributions to the greenhouse effect;

- Reduce the City's corporate energy requirements by vehicles, buildings, equipment and programmes to reduce cost and demand on resources; and

- Affect more intensive land use planning that is more energy efficient.

The energy management aspects of the city's environmental strategy are being developed by a specially constituted Task Force on the Atmosphere.[26] In 1992, the City of Ottawa made a commitment to reduce city-wide carbon dioxide emissions by 20% by the year 2005. The Task Force on the Atmosphere was a city Council-approved initiative of the Environmental Management Branch, Department of Engineering and Works. Membership consists of community representatives, representatives from major stakeholders in the energy sector, and experts in energy and climate change.

The Official Plan already specified a number of policies for the encouragement of energy efficiency and renewable energy in the city, including the promotion of mixed-used development that reduces the number of distance of vehicle trips, the

25. City of Ottawa, "Environmental Conservation and Management Strategy: Phase II -- The Environmental Agenda", Department of Engineering and Public Works, Environmental Management Branch, City of Ottawa, June 1992.

26. Contact: Paul MacDonald, Coordinator, Environmental Management Branch, Department of Engineering and Works, City of Ottawa, 111 Sussex Drive, Ottawa, Ontario, Canada, K1N 5A1. Tel: (613)-564-4417, Fax: (613)-564-4617.

encouragement of urban forestry practices that will reduce energy consumption of buildings, and consideration of energy issues in the approval of new developments (including a requirement for solar access). The mandate of the Task Force on the Atmosphere is to work with city staff in developing an action plan that will meet the city's commitment for a 20% reduction in carbon dioxide emissions. Task Force members are committed to actively participate in both the development and implementation of the Action Plan. Using a study of the city's 1990 CO_2 emissions as a starting point,[27] and a list of technical measures for reducing carbon dioxide measures (included as Appendix B to this report), the Task Force is identifying the measures with greatest relevance to the City of Ottawa energy profile and developing proposals for the ways and means of putting the priority measures in place. The Task Force is working toward a May 1995 deadline for having a Final Action Plan.

3.3.7 Vancouver's Clouds of Change Initiative

The City of Vancouver has had an internal energy conservation programme since 1977 and the accumulated savings of measures implemented as part of this programme are now more than $1,500,000 per year.[28] Like Regina, they have solved the problem of "up-front" financing costs for energy conservation measures by making "in-house" loans available. The city's finance department arranges funding for energy conservation projects and retrofits through the Property Endowment Fund, which is repaid with interest from the savings in fuel and electricity costs. The city's policy is to approve measures with paybacks up to seven years, and this has allowed relatively expensive (but still cost effective) lighting retrofits and computer energy management systems to be installed in the city's buildings. There is an ongoing and extensive programme to retrofit the mechanical and electrical systems of the city's 400 buildings and, like many other Canadian cities, the streetlights have been converted from incandescent and mercury vapour to high pressure sodium lamps. In general,

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27. Kai Millyard, "A Preliminary Carbon Dioxide Inventory for the City of Ottawa", prepared for the Climate Change and Energy Program of Friends of the Earth Canada under contract to the City of Ottawa Department of Engineering and Public Works, February 1992.

28. Contact: Mr. Kevin Kwok, P.Eng., Asbestos Control/Energy Conservation Officer, Housing and Properties Department, City of Vancouver, 453 West 12th Avenue, Vancouver, B.C., Canada V5Y 1V4. Tel: (604)-873-7165, Fax: (604)-873-7064.

in-house energy management is a well developed and ongoing activity in the City of Vancouver, complete with innovative financing and extensive partnership with the electrical utility's demand management programmes.

Vancouver also has a history of supporting energy conservation and renewable energy development in the community. This has included information and awareness campaigns, residential energy audits, and a demonstration project involving the retrofit of an old building with advanced energy efficiency technologies. The building is rented for $1/year to the Society for the Promotion of Environmental Conservation, who operate it both as model and an information centre. As early as 1979, Vancouver City Council adopted a "Framework for a Vancouver Energy Strategy" as its preliminary statement of energy intent. Council also authorized dissemination of the framework to encourage public discussion and debate of Vancouver's energy future and of the City's role in energy policy.

Most recently, concern over air quality has stimulated renewed interest in Vancouver in the possibilities of city-wide energy management for environmental improvement. Vancouver established a Task Force on Atmospheric Change, comprised of citizens representatives, experts and city staff, which issued a report in 1990 entitled Clouds of Change.[29] The report included 35 detailed recommendations for improving air quality and reducing carbon dioxide emissions in the City of Vancouver. The recommendations covered many aspects of air quality, and several of the recommendations focused on the role of energy management. Highlights include:

- Increasing energy efficiency by 10% in all sectors of the city by the year 2000;
- Reducing the need for transportation in the region by land use planning tools such as residential intensification, energy efficient land use policies, ecological development incentives, and rezoning;

29. City of Vancouver, Clouds of Change -- Final Report of the Task Force on Atmospheric Change, two volumes, June 1990. Also see City of Vancouver, *"Clouds of Change: Recommendations as Amended and Adopted by Vancouver City Council"*, October 16, 1990.

- Promoting bicycling, public transport, telecommuting and high occupancy vehicles;
- Implementing a regional carbon tax;
- Enacting an energy utilization by-law requiring all new commercial and multi-family residential buildings to meet a city building code. The code applies to all new buildings in Vancouver except for 1 or 2 family homes, and is a modified version of the ASHRAE 90.1 (1985) Code[30]. The administrative cost will be recovered from permit fees: it is estimated that the energy savings from this by-law alone will result in energy over the next 20 years equal to the energy needs of about 50,000 new homes.

Not all the recommendations of the Clouds of Change report have been adopted and implemented, but many of them have and the initiative is an outstanding example of how environmental improvement is becoming a driving force for urban energy management in Canada. The energy utilization by-law is a particularly interesting initiative, insofar as the building codes are typically a provincial responsibility in Canada. The City of Vancouver has a Charter from British Columbia which gives it more well-defined powers in this area than most Canadian cities, but other cities are also finding that "informal" conditions on building permits can be an effective way to achieve energy efficiency in the design of new buildings.

The *Clouds of Change* initiative also underscores the extent to which municipal freedom of action is constrained by the limited powers of local governments in Canada. The implementation of a local carbon tax, for example, requires provincial approval and has not gone ahead. In a number of other areas, the recommendations of the Vancouver Task Force on Atmospheric Change could be no stronger than to "lobby the provincial or the federal government" to implement measures that would lead to reduced urban energy use and air quality improvement (eg. mandatory vehicle emission testing, sliding scales for vehicle permits and insurance, legally enforceable vehicle efficiency standards).

30. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings, ASHRAE Standard 90.1-1989, available from ASHRAE, 1791 Tullie Circle, N.E., Atlanta, Georgia, USA 30329.

3.3.8 The Federal Buildings Initiative (FBI)

The federal government is a major building owner in Canadian cities and has recently launched an energy efficiency investment programme designed to allow government departments to contract for energy management retrofits in their buildings in a manner that will avoid front end costs by financing the retrofits with the resultant savings in energy costs. The Federal Building Initiative[31] (FBI) facilitates contractual arrangements involving a utility, a pre-qualified energy management firm and a federal department or organization in which the department has an energy management firm supply and install energy saving equipment. The department then pays the resulting lower energy bill to the utility and an amount equivalent to the energy savings to the management firm, until the full cost of the energy efficiency retrofit is recovered. Departments are guaranteed that there will be no real increase in their total energy costs (including the payments for the retrofit).

Under the FBI, the financing for the energy retrofits in federal buildings is arranged by the energy management companies contracted to do the work, but the programme encourages this type of activity by providing advice, sample contracts, technical information and a list of pre-qualified energy management companies. In addition to the direct impact the increased level of energy efficiency will have in the communities with participating federal buildings, the programme encourages the development of the Canadian energy management industry by organizing and promoting energy management by the country's largest building owner -- the federal government.

3.3.9 Ontario Municipal Energy Improvement Facility: Leveraging Private Capital

In 1993, the International Council for Local Environmental Initiatives, with support from the Ontario Ministry of Environment and Energy, established the

31. Contact: Jean-Pierre Des Rosiers, Director, Energy Efficiency Programs, Efficiency and Alternative Energy Branch, Natural Resources Canada, 580 Booth Street, Ottawa, Canada, K1A 0E4. Tel (613)-996-7512, fax (613)952-8169.

Ontario Municipal Energy Collaborative (OMEC)[32], a pilot project consisting of eleven Ontario municipalities interested in developing more strategic and comprehensive approaches to urban energy management.[33] The project set the following goals:

- to leverage private capital for urban energy management through innovative financing schemes that would allow government funding for energy efficiency investments to multiplied several-fold through risk underwriting and securitization;
- to apply strategic analysis to the potential for urban energy management by evaluating the potential for energy efficiency improvements in all municipal buildings over a range of paybacks that goes well beyond the traditional "five year payback ceiling" typical of local government conservation spending;
- to "market energy efficiency to municipal councils" through stressing the multiple benefits of energy conservation and actively soliciting the support of city council members for comprehensive urban energy management programmes;
- to develop strategic procurement policies that take advantage of the considerable aggregate purchasing power of the project's member cities by creating market opportunities for Canadian companies while ensuring the best possible price and quality for the OMEC member cities; and
- to increase awareness of the unique needs of the municipal sector among the manufacturing, engineering, contracting and financing sectors with the ultimate goal of creating new technology, service and financing products that are targeted at the urban energy management market.

32. Contact: Phil Jessup or Dan Goldberger, Ontario Municipal Energy Collaborative, International Council for Local Environmental Initiatives, 8th Floor, East Tower, City Hall, Toronto, Ontario, Canada, M5H 2N2. Tel: (416)-392-1462, Fax: (416)-392-1478.

33. The membership of the Ontario Municipal Energy Collaborative includes the cities of Burlington, Kitchener, Mississauga, North York, Ottawa, Peterborough, Scarborough, Toronto, and Sudbury, and regional municipalities of Sudbury and Metropolitan Toronto.

In the initial phase of the project, ICLEI consultants worked with the energy and building managers in the OMEC member municipalities to develop profiles of total building energy use and related costs, and to estimate the potential for comprehensive energy efficiency improvements. A total of 650 buildings (31 million square feet) were included in the analysis, with a collective fuel and electricity bill in 1992 of about $44 million. Deliberately looking at the potential for "deep savings" in these buildings that would have significant long term environmental benefits, the analysis indicated that savings of 37% of fuel and electricity costs could be realized with measures with 5-10 year paybacks and a total investment in the range of $120-$140 million.

Building on the results of this initial phase, the International Council for Local Environmental Initiatives went on to develop a proposal for an *Ontario Municipal Energy Improvement Facility* that represents one of the most interesting innovations to date in Canadian urban energy management. The proposed facility, which is being planned in partnership with a major Canadian financial institution, will centre around a $100 million revolving loan programme that will provide financing for energy management projects in the pilot market.

By aggregating the municipal energy management market and arranging for the financing of the energy retrofits, the facility helps remove one of the central barriers to urban energy management -- access to low cost capital. In addition, a number of other services are planned which are made possible by the economies of collaboration:

- strategic planning that identifies the energy efficiency investment potential in a municipality's building stock, formulates a pragmatic staged approach to retrofit improvements, and provides an integration path with federal and provincial infrastructure programmes;
- a talent bank of demand-side management specialists, a pool from which the municipalities and the fund managers can draw for consulting and project implementation;
- a Guaranteed Energy Savings Pool, an insurance mechanism that would pay back to the municipality the difference between the cost of the energy project and savings, where such costs exceed savings;

- customized procurement of energy services, including energy efficient products and equipment; and
- monitoring and verification services that precisely measure the energy savings from retrofits.

The proposed facility addresses most of the barriers faced by municipalities seeking to implement energy management for environmental improvement and represents a significant strategic breakthrough for the development of urban energy management in Canada.

3.3.10 Toronto's Atmospheric Fund and the Green Economic Initiative: Making the Links to Sustainable Development

Toronto was the first city in the world to make a commitment to reducing carbon dioxide emissions on a city-wide basis and has taken a number of initiatives toward that goal in the last several years.

Toronto Atmospheric Fund. In 1992, some of the proceeds from a property sale were used to establish the Toronto Atmospheric Fund with an initial balance of approximately $23 million. The purpose of the fund is to finance special projects for addressing atmospheric environmental issues in the City of Toronto and it is administered by an independent board of directors.

Energy Efficiency Office. In 1991, the City of Toronto established an Energy Efficiency Office (EEO) with a mandate to develop and implement a comprehensive energy strategy for the City. This strategy goes beyond the management of the City's own buildings and includes staffing, research, and programme financing of a city-wide strategy. The Energy Efficiency Office, which by mid-1994 had a staff of ten, has become the hub of a great deal of activity related both in-house and city-wide energy management initiatives in Toronto.

Retrofits of City Buildings and Streetlighting. A total of 268 buildings were audited in partnership with Ontario Hydro under the Power Savers Programme. The total cost of electrical retrofits was estimated to be 4.6 million dollars, with project financing secured through the Toronto Atmospheric Fund. Retrofits to municipal facilities are currently underway. The street and lane lighting conversion programme began last year and involves the installation of approximately 40,000 metal halide lamps at this project's completion in the fall of 1994. Ontario Hydro has contributed $2.2 million to the total programme cost of $15.5 million. This programme will reduce electrical demand by 6.4 MW.

Studies of Conservation. A number of studies were commissioned on the potential for electricity and fuel savings potential in each of the major consuming sectors (residential, commercial, industrial, transportation) and these studies are being used the Office of Energy Efficiency to formulate its strategies. It was found that the economic potential for electricity savings in Toronto was of the order of 41% to 46%, with similarly impressive savings potentials of oil and gas. These studies showed that the achievement of the City's 20% CO_2 reduction target was economically feasible, but would require going much further than was typical of energy efficiency programmes.

Energy Efficiency and Conservation Plans. The Energy Efficiency and Conservation Plan programme began in 1991 and makes it a condition for obtaining a building permit in the City of Toronto that an Energy Efficiency and Conservation Plan for the proposed building be submitted to the Energy Efficiency Office for review. For the commercial, institutional and industrial sectors, the review and approval process is based on ASHRAE/IES Standard 90.1 - 1989. For low rise residential buildings, the Canadian Federal Standard R-2000 is used. The Energy Efficiency and Conservation Plan is being amended (1994) since under the Ontario Building Code (September 1993), all new commercial, institutional and industrial buildings are to be built to ASHRAE/IES Standard 90.1 - 1989.

Looking toward the future, Toronto's proposed **Green Economic Initiative** represents the most advanced approach being taken to urban energy management for environmental improvement in Canada. It includes innovative features to overcome all the barriers that typically face urban energy management initiatives and it combines all the positive elements of sustainable urban economic development -- community involvement, environmental targets, business partnership, innovative financing, comprehensive coverage, integrated programmes, and political leadership.[34] The basic premise of the initiative is that there is positive synergy between environment and economy. This premise has carried forth into an initiative that seeks to obtain energy and water reductions of the order of 30% by retrofitting every home and business in the City of Toronto.

At the heart of the Initiative is the desire to create employment in the trades and manufacturing. It is hoped that this employment will foster the development of Toronto-based skills and technologies that will improve the urban and global environment. The urban environment will be improved by the reduction in stationary sources of fossil fuel combustion emissions. Also Toronto's beaches on Lake Ontario will be improved through a reduction of sewage discharges; the sewage itself will be treated better because inflows will be reduced. The Initiative also incorporates investigations into the expansion and diversification of the Toronto District Heating System which provides steam to the downtown core area as well as the development of a plan to use lake water for cooling.

This initiative is being designed as a self-financing programme. The pilot phase of this programme will differentiate between "one-time" start-up costs and ongoing financial requirements to make the programme self-sustaining. The ongoing financial requirements represent the component that will be self-financing, ie. the administrative costs, costs of financing as well as the costs of the measures themselves will be recovered from the energy savings. Discussions are underway with a broad range of financial and investment sources in order to produce a feasible financial model including investment mechanisms for the programme.

The City of Toronto Energy and Water Savings Pilot Programme includes participation from the major energy providers to the City of Toronto, namely, Ontario Hydro, Toronto Hydro and Consumers Gas. These utilities are participating in the detailed design and implementation plans for this initiative under a group called the Toronto Environmental Partnership. Details pertaining to the actual roles and responsibilities of the partners as well as the process employed will be determined through the pilot project design.

34. Contact: Nicholas Vardin, Commissioner of Public Works and the Environment, City of Toronto, City Hall, Toronto, Ontario, Canada, M5H 2N2, Tel: (416)-392-7763, Fax: (416)-392-0816.

Development of this programme is the administrative responsibility of the Department of Public Works and the Environment under the auspices of a Special Committee of Toronto City Council - The Energy and Water Savings Committee (EWSCO). the committee is comprised of five members of City council, and this high level of political involvement has been key to its expeditious progress.

The goal of the Green Economic Initiative is to retrofit every home and business in the City of Toronto. A participation rate of 75% is targeted, and if successful the total investment will be about $3 billion when the project is finished.

The Toronto Green Economic Initiative represents the most advanced approach being taken to urban energy management for environmental improvement in Canada and possibly anywhere. It includes innovative features to overcome all the barriers that typically face urban energy management initiatives and it combines all the positive elements of sustainable urban economic development -- community involvement, environmental targets, business partnership, innovative financing, comprehensive coverage, integrated programmes, and political leadership (see Figure 6, p.18).

4. OBSERVATIONS AND CONCLUSIONS -- ENERGY AND SUSTAINABLE URBAN COMMUNITIES

From the above review of the experience that has been gained in Canada, a number of observations can be made with respect to the rationale for urban energy management, common barriers to its implementation, and key factors that appear to be ingredients for success.

4.1 Multiple Benefits and Synergies: The Rationale for Municipal Action for Energy-Related Environmental Improvement

Urban energy management brings multiple benefits to municipalities; environmental improvement is just one important factor in motivating cities to pursue conservation, efficiency and renewable energy developments; there are many others:

- *Financial Savings.* The prospect of savings in their operations budgets is often the starting point for municipal energy management initiatives. Municipalities are large organizations that own and maintain all sorts of buildings, including offices, hockey arenas and swimming pools, recreational and community centres, fire stations, and public housing. They own and operate fleets of automobiles, trucks and various special purpose vehicles; they pay the electricity bill for streetlighting; and they usually are responsible for the operation of water supply and sewage treatment facilities. Fuel and electricity are significant cost items for these organizations and the energy bill emerges as an important cost cutting target as city managers face increasing pressure to reduce operating expenditures. Fuel and electricity costs amount to tens of millions of dollars per year for the larger Canadian cities.

  Metropolitan Toronto, for example, spent $23.8 million on fuels and electricity in 1992 for its buildings and for streetlighting, *but not including* water pumping, water treatment, sewage treatment or vehicle fuel. And this is only part of the story, as the six individual member municipalities of Metro Toronto (including the City of Toronto itself) also operate buildings, vehicle fleets and streetlighting; the total energy bill would more than double if these costs were included in the total.[34] With potential cost effective savings in the 10-20% range, multi-million dollar annual savings are achievable.

- *Job Creation.* Energy management activities, and especially energy efficiency improvements, are among the most efficient investments when it comes to job creation. This is partly because there is a relatively high labour component in activities such as building energy retrofits, but more importantly it has to do with the "respending effect". When energy management activities reduce expenditures on fuel and electricity, the savings are then "respent", usually within the community, and very often in the service sector where the ratio of employment generated to money spent is particularly high. The estimated size of the "demand side employment advantage" depends on local situations; research in this area indicates that, dollar-for-dollar, energy management creates 1.5 - 5 times as much employment as spending on energy supply.[35] It is interesting to note that the federal government's "Eneraction" programme of the late 1970's, which promoted community energy conservation centres across the county, was motivated as much by employment policy as energy policy, and was largely funded by money set aside for job creation.

- *Local Economic Development.* The energy management industry itself is a growth industry and its promotion can be an effective component of community economic development strategies. There is a double benefit to the development of this industry: in addition to the business and employment generated in the provision of energy management products and services there is also the impact of the "respending effect" as individuals and businesses realize the savings on their fuel and

34. Data for Metro Toronto taken from Torrie Smith Associates, "Inter-City Comparisons of Building Energy and Water Data", prepared for the Ontario Municipal Energy Collaborative, International Council for Local Environmental Initiatives, November 1993.

35. See Mark Jaccard and David Sims, "Employment Effects of Electricity Conservation: The Case of British Columbia", Energy Studies Review, Volume 3:1, pp. 35-44, 1991; Howard Geller, J. DeCicco and S. Laitner, Energy Efficiency and Job Creation: The Employment and Income Benefits from Investing in Energy Conserving Technologies, American Council for An Energy Efficient Economy, Washington, D.C., and Economics Research Associates, Oregon, October 1992; Leonard S. Rodberg, "Employment Impact of Alternative Energy Demand/Supply Options", Exhibit 991, Ontario Hydro Demand/Supply Hearings, Ontario Environmental Assessment Board, 1992; Torrie Smith Associates, "Employment Impacts of Energy Efficiency: Literature Review and Implications to Newfoundland", Innu Nation, 1993; and Ian Goodman et. al., Employment Effects of Electricity Provision in Quebec: The Great Whale Hydroelectric Project and the Electricity Efficiency Alternative, The Goodman Group, Boston, Mass., 1992.

electricity bills and respend those savings in the community. Energy management activities have long been associated with the concept of local self-reliance and community economic development.[36]

- *Partnership Potential.* Municipalities often get into energy management activities in response to encouragement and incentives offered to them by other levels of government or by utilities seeking to promote demand side management. Energy efficiency goals set by higher levels of government (perhaps related to CO_2 emission reduction objectives) will usually require the active support and cooperation of local governments. Most energy users are urban dwellers; urban governments are well suited to the type of integrated programme delivery often required to achieve energy efficiency objectives; the population density of urban settlements results in scale economies in the delivery and marketing of energy management programmes; and perhaps most importantly, the demand for fuels and electricity in the society is determined to a large degree by urban form and land use patterns, both of which are largely determined by local government policies. Participation in government and utility programmes for energy management can often help local governments achieve their own policy objectives while bringing them other benefits as well.

- *Local Air Quality.* Energy management initiatives are among the most cost effective actions that can be taken to reduce the air pollution that represents such a serious environmental problem in so many cities. Concern over local air quality is often cited as an important reason for urban energy management initiatives, and has probably been the most important factor in the growing interest in energy management in the City of Vancouver.

- *Global Warming.* Concern over the "greenhouse effect" and the realization that climate change represents a problem that must be tackled by all levels of government has led many local governments to declare targets for the reduction of CO_2 emissions in their community. Among Canadian cities, a commitment to reduce greenhouse gas emissions has been made by Edmonton, Ottawa, Toronto, Regina, Vancouver and Victoria, as well as the Regional Municipality of

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36. David Morris, Self-Reliant Cities: Energy and the Transformation of Urban America, Institute for Local Self-Reliance and Sierra Club Books, San Francisco, 1982.

Metropolitan Toronto[38]. In general, the commitment has been made at the political level and the strategies for achieving the objectives are still being formulated. As these cities proceed to translate their commitments into action plans, energy management initiatives are invariably among the highest priorities.[39]

- ***The Greening of the City.*** Another path to local government interest in energy management for environmental improvement is the more general interest local governments have been developing in creating healthy and environmentally sustainable cities.[40] Canada Mortgage and Housing Corporation has played a leadership role in Canada by sponsoring research and promoting the concept of sustainable housing and residential land use planning.[41] Any consideration of how to achieve sustainable cities will necessarily require consideration of how to achieve sustainable urban energy use patterns. From planning and maintenance of road and transit systems to the allocation of land to parks and greenspace, to the design, through official plans, of urban settlement patterns, municipal governments already play a large if

38. Tanya Imola, "Survey of Municipal Actions on Climate Change in Canada", International Council for Local Environmental Initiatives and Federation of Canadian Municipalities for Environment Canada, September, 1993.

39. Ralph D. Torrie, "Strategic Analysis of Municipal Policies for Carbon Dioxide Emissions Reductions -- Some Methodological Issues and Modelling Techniques", prepared for Urban CO_2 Reduction Project, International Council for Local Environmental Initiatives, November 1991; also International Council for Local Environmental Initiatives, Urban CO_2 Reduction Project, Local Action Plans of the Municipalities in the Urban CO_2 Reduction Project, March 1993.

40. See for example, Richard Stren, Rodney White and Joseph Whitney, eds. Sustainable Cities: Urbanization and the Environment in International Perspective, including a chapter on Canada by Nigel H. Richardson, Westview Press, 1992; Mark Roseland, Toward Sustainable Communities: A Resource Book for Municipal and Local Governments, National Round Table on the Environment and the Economy, (1 Nicholas Street, Suite 1500, Ottawa, Canada K1N 7B7), 1992; David Gordon, ed. Green Cities: Ecologically Sound Approaches to Urban Space, Black Rose Books, 1990; Royal Commission on the Future of the Toronto Waterfront, Regeneration: Toronto's Waterfront and the Sustainable City: Final Report, Government of Canada and Province of Ontario, 1992; Richard Register, Ecocity Berkeley: Building Cities for a Healthy Future, North Atlantic Books, Berkeley, California, 1987; Swedish Environmental Advisory Council, Eco-Cycles: The Basis of Sustainable Urban Development, Stockholm, 1992; Jeb Brugmann, "Managing Urban Ecosystems: An Introduction to the Principles for Ecological City Management", International Council for Local Environmental Initiatives, Toronto, 1992.

41. See David D'Amour, "Towards an Investigation of Sustainable Housing" Sustainable Development and Housing Research Paper No.2, Research Division, Canada Mortgage and Housing, July 1993. For other housing-related environmental research, see "CMHC Research Activities Which Address Environmental Concerns", CMHC, Ottawa, May 1994. Available from Canada Mortgage and Housing Corporation, 700 Montreal Road, Ottawa, Ontario, Canada K1A 0P7.

unappreciated role in determining energy use patterns. In the context of creating environmentally sustainable communities, the challenge is to make this role explicit and to identify and make the changes necessary for environmental improvement.

This is no doubt an incomplete list of the reasons why local governments are becoming more involved in energy management, but there is little doubt that their interest will continue to grow because energy management helps to achieve so many other goals which are important to them.

4.2 Barriers to Municipal Energy Management in Canada

There are a number of obstacles which can get in the way of successful urban energy management for environmental improvement in Canadian cities; the following summarizes the more important and pervasive ones.

- ***Failure to Realize the Possibilities.*** Before a municipality can embark on a successful programme of energy management, it must see the opportunity and the possibilities. The conceptual framework depicted in Figure 6 may seem simple, but even getting to the point where each of these three "realities" is properly defined and understood is a difficult task; understanding the relations between them is even more difficult. For local governments in Canada to recognize the potential of urban energy management, it must be seen as an opportunity for achieving other objectives held by the local government and for benefitting from the partnerships that can be formed with other governments and businesses with an interest in promoting energy management.

- ***Constitutional and Legal Barriers.*** Energy policy is not an explicit responsibility of municipal government in Canada. In addition, pricing of electricity is centrally regulated; even when municipalities own and/or operate the local distribution utility, the price they can charge for the electricity is determined by the central government, which often owns the power company supplying the electricity. While some municipalities have *de facto* municipal building code that "requires" minimum energy efficiency standards be met before permits are issued, such codes rely on voluntary compliance and in most provinces are not legally enforceable because the power to enforce such codes has not been formally delegated to the municipal governments. The provinces also impose restrictions on the types of investments and programmes that municipalities can pursue, for example, by prohibiting the use of municipal funds for energy conservation and efficiency loans to members of the community[41].

- *Information Gaps*. Energy statistics are not generally collected or organized at the municipal level and energy policies are not generally formulated within an urban context. Those Canadian cities that have attempted to develop a simple end-use disaggregated profile of urban energy use have found it a difficult task. Energy management is an information-intensive resource and the measures and technologies that are applied to achieve energy management have very high information content. The "up front" costs of developing an adequate information base upon which to proceed with urban energy management programmes represent an important barrier to local governments that wish to pursue energy management for environmental improvement.

- *Lack of Analytical Capacity*. Closely related to the dearth of information available to support urban energy management is a lack of energy expertise and analytical capacity within city governments. Energy management is a fairly newly discovered "resource" even among energy experts, and the analytical capacity for supporting strategic investment and policy decisions does not exist in most municipal government organizations. In this regard, one of the important benefits of a strong in-house energy management programme is that it builds up experience and familiarity with the information, modelling tools and analytical methods that are necessary to plan and execute effective energy efficiency, conservation and renewable energy projects.

- *Financial Constraints*. Once a city has committed itself to pursuing urban energy management for environmental improvement, the most often cited barrier to implementation is lack of finances. The problem is only partly a shortage of funds; it is also partly the absence of a strategic approach to energy management investments. In fact, even in-house spending on energy management is rarely evaluated from a strategic investment perspective. More often than not, annual spending on energy efficiency and other energy management initiatives in the

41. For a municipal perspective on legal and constitutional barriers to municipal energy management initiatives, see Jack Layton, "Energy and Environmental Decision-Making in Toronto: An Overview", prepared for the Urban Development and Environmental Management Program, April 1993. Available from Dr. Layton at 8 Bulwer Street, Toronto, M5T 2V3; Tel. (416)-351-0301, Fax (416)-351-0304. Also, see Harry Poch, "Energy Conservation and Efficiency Programs: Legislative Issues", prepared for the Ontario Municipal Energy Collaborative Symposium, June 1993. Available from the Ontario Municipal Energy Collaborative, c/o International Council for Local Environmental Initiatives, 8th Floor, East Tower, City Hall, Toronto, M5H 2N2.

city's own buildings is not only quite limited (relative to the annual fuel and electricity bill) but is subjected to the most stringent, short-term, simple payback criteria, almost always less than five years. To achieve energy savings that can start to have a significant impact on emissions and other environmental impacts requires going beyond the "five year simple payback ceiling" and to do this energy management must be seen as a strategic investment. Even if this transition can be made, cities may not be willing or able to put up the money for the larger and longer payback investments required, and energy management for environmental improvement will depend heavily on the success of emerging techniques for innovative third party financing and risk underwriting.[42]

4.3 Urban Energy Management for Environmental Improvement -- Keys to Success

- *A Strategic Approach.* Urban energy management for environmental improvement requires innovation and initiative; it won't happen spontaneously because it requires a combination of elements that is not part of the traditional mandate or conventional operations of municipal government in Canada. It must therefore be driven by an impetus strong enough to overcome the inertia of "business as usual" and this requires that it be guided by a long range, strategic approach.

- *Environmental Targets.* The role of clearly specified environmental targets (eg. 20% reduction in CO_2 emissions, elimination of ozone depleting chemicals, etc.) is critical in urban energy management for environmental improvement. Without explicit objectives related to environmental improvement, urban energy management ceases to be urban energy management *for* environmental improvement. If goals are not derived from an analysis of what is necessary to improve the environment, then the results may not be sufficient to be of much environmental consequence.

42. For an excellent introduction to this emerging field of energy management financing, see Dan J. Goldberger, Philip Jessup, Jenny Fraser and Stuart Baird, Profiting from Energy Efficiency! A Financing Handbook for Municipalities, International Council for Local Environmental Initiatives, Toronto, 1993. Available from ICLEI, City Hall, East Tower, 8th Floor, Toronto, Ontario, M5H 2N2, Tel (416)-392-1462, Fax (416)-392-1478.

- *Recognition of Multiple Benefits.* Even in cases where environmental improvement has been the original motivation for developing a comprehensive urban energy management programme, when the program is packaged and "marketed" both to city council and to the public, it is done on the basis of the multiple benefits that flow from energy conservation actions. Job creation, community economic development, and cost savings are among the other benefits cited as reasons for pursuing urban energy management.

- *Political Leadership.* Mounting urban energy management programmes that go beyond in-house savings requires not just passive political support but active involvement, encouragement and leadership from city council. In fact, urban energy management programmes in Canada have often been initiated at the political level, for example through the passing of a resolution of city council calling for the reduction of carbon dioxide emissions in the community. Urban energy management strategies cannot go far without the explicit support of city council; they require staffing or money or corporate decisions that can only be granted by the council.

- *Community Involvement.* Related to the need for political leadership is the need for community involvement in the design and delivery of energy management programmes. All the successful urban energy management programmes to date in Canada have had a strong component of community involvement. In the early stages of mounting an urban energy management strategy it is possible to accomplish a great deal through the use of centralized financing and technical resources; in the long term, the levels of energy management and the types of changes that will be required to put Canadian cities on a sustainable basis will only be possible with the consent and involvement of their citizens.

- *Bureaucratic Support.* If active political support is necessary for successful urban energy management, so too is enthusiastic support from the city staff. Urban energy management programmes require bureaucratic innovation and entrepreneurial managers who can overcome entrenched institutional structures and interests. Successful energy management programmes exist where individuals or groups of individuals inside city governments have embraced the concept, are excited by the challenge it presents, recognize the benefits it can bring to their city, and realize its potential for professional development and career advancement.

- ***Partnership.*** Canadian cities can accomplish much more through partnerships with senior levels of governments, utilities and others with an interest in urban energy management than they can by going it alone. Not even the largest Canadian cities have all the necessary information, analytical, financial, marketing, and technical skills and resources for mounting integrated, comprehensive and effective urban energy management programmes. As they develop, partnerships almost always yield benefits far beyond those identified at the outset.

- ***Innovative Financing.*** Even for in-house conservation programmes, and especially for city-wide efforts, the up-front investment costs are a major obstacle. Innovative methods for attracting investment capital are essential for success. Governments with environmental policy objectives that require achieving the "deeper savings" with the longer paybacks can stimulate the necessary investment by acting as guarantors and by providing quality assurance and industry standards which increase investor confidence that the risk is minimal. The proposed Ontario Municipal Energy Improvement Facility is an excellent example of how this can be done, as is the Federal Buildings Initiative.

- ***Collaboration with Other Local Governments.*** The strength and mutual support gained by collaboration with other municipalities with similar objectives and policies are invaluable, especially in the early stages when methods and approaches are still at the experimental stage. The use of joint procurement strategies which has been developed for some types of products and services, holds great potential in the field of urban energy management. There is also a great deal of highly specialized, technical expertise in city governments with regard to energy efficiency measures that have been undertaken on city buildings over the past twenty years of energy conservation initiatives. This pool of experience represents a significant resource and the sharing of energy management knowledge and techniques between cities is another important mutual benefit of inter-city collaboration.

- ***Integrated Programme Delivery.*** Energy management programmes are most effectively delivered as part of an integrated environmental improvement strategy. Water conservation, waste reduction and recycling, land use and other elements of a city's environmental strategy should be integrated, especially with respect to programme delivery and public education and outreach.

As stated at the outset, urban energy management for environmental improvement is still a new idea in Canada, but already there are some outstanding examples of innovation and initiative among the efforts that have been mounted to date. Only in the last few years have urban governments in Canada begun to perceive of their function in terms of environment and sustainable development, and that is leading to profound changes in their planning principles and policies.

The opportunity for municipal governments to become much more significant players in urban energy management for environmental improvement has only recently been identified and true urban energy management for environmental improvement is still in its early stages in Canada. The task ahead is to gain an understanding of the energy system at the urban level, an appreciation of how urban policies and programmes can affect that system, and to establish priorities for making changes that will lead to significant environmental improvement.

APPENDIX A

OVERVIEW OF ENERGY AND ENVIRONMENT IN CANADA

1 PATTERNS OF CANADIAN ENERGY SUPPLY AND DEMAND

In 1992, per capita use of fuels and electricity in Canada totalled 320 GJ, more than double typical levels in western Europe, more than five times the world average, and over 25 times higher than the average for African nations (see Figure A-1). Both the level and rate of improvement of the energy productivity of the Canadian economy are low by world standards. There are many reasons for this high level of energy use, including lifestyle, climate, industrial structure, distances between centres, relatively low energy prices, and a somewhat lower emphasis on energy conservation and efficiency than has been the case in many other OECD nations.

Total use of fuels and electricity in Canada, including power plant losses and the energy industry itself, is illustrated in Figure A-2, disaggregated by fuel, and in Figure A-3 disaggregated by consuming sector. Figure A-4 provides a profile of Canadian energy use disaggregated by both fuel and sector. The energy use represented here is total domestic use of fuels and electricity, net of exports and non-energy uses. In the disaggregation by fuel, for fossil fuel-fired power plants, output is counted as electricity and thermal losses are counted as part of the total for the relevant fossil fuel. In the disaggregation by sector, the Energy Industry includes the thermal power plant losses, as well as the fuels and electricity consumed by the oil, gas, coal and electricity industries in the manufacturing, refining and delivering of their products.

In terms of the types of energy end uses for which fuels and electricity are demanded in Canada the pattern, illustrated in Figure A-5, is typical of other advanced, industrial economies[1]. Over half the final demand for fuels and electricity is for heat applications, with 29% for low temperature heat (space and water heating) and 24% for industrial process heat, including medium temperature (steam plant) applications and high temperature (furnaces and kilns) applications. Liquid fuels, mostly for transportation, account for 33% of the final demand for energy in Canada and the remaining 13% consists of electricity specific applications (electronics, motive drive, home appliances, lighting, electrochemistry, and other end uses for which electricity is either theoretically or *de facto* the only energy source).

In most of Canada, electricity production has developed via state monopolies operating at the provincial level and there are marked differences in the mix of primary fuels used to make electricity from one province to the next, as illustrated in Figure A-6. British Columbia, Manitoba, Quebec and Newfoundland produce almost all their

1. In the case of sector and fuel breakdown, the figures presented are based on fairly reliable "official statistics, which are in turn based on fuel and electricity data sales data and national surveys of energy users. As is still the case for most of the OECD nations, Canada does not collect and maintain end use data on a comprehensive and systematic basis. The end use breakdown presented is therefore necessarily an estimate based on the literature and the author's own expertise in this field of research.

electricity from hydropower; Alberta, Saskatchewan and Nova Scotia are heavily dependent on fossil-fired thermal generation; Ontario and New Brunswick have a mix of hydro, nuclear and fossil-fuelled stations. These differences are important in considering the environmental consequences of electricity production in different regions of the country.

The "snapshot" of Canadian energy use provided by Figures A-2 through A-6 reveals energy use patterns fairly typical of industrialized economies, with some deviations reflecting Canada's unique climate, industrial structure and energy policy history.

In terms of sector disaggregation, the industrial sector, including the energy industry itself, accounts for fully 52% of the domestic demand for fuels and electricity. Further, this industrial energy use is heavily concentrated in a small group of energy-intensive industries -- pulp and paper, mining and smelting, primary metals refining (including steel), industrial chemicals, and the energy industry itself. This group comprises fully 80% of all industrial energy use and about 42% of the total use of fuels and electricity in Canada. Industrial energy use is heavily dominated by process heat which is believed to represent some 75-80% of industrial energy use, with the remainder being comprised primarily of motive power. Industry has turned heavily to natural gas in recent years.

Transportation energy use is the next largest consuming sector; it accounts for about 22% of the domestic demand for energy (with the energy industry included in the total) and about 30% of the final demand for fuels and electricity. It is almost totally based on petroleum fuels, and as a result represents by far the largest remaining area of oil dependence for the Canadian economy. The residential and commercial buildings sector comprise the remaining 25% of Canadian fuels and electricity consumption, with space and water heating being the largest contributors to the end use demand in these sectors.

The evolution of the domestic demand for fuels and electricity is illustrated in Figure A-7, which traces Canada' primary energy demand from 1926. Petroleum maintains a 40% share of total Canadian energy use. This is down from its high of 57% in the late 1960's, reflecting the emphasis on switching "off oil" in the Canadian response to the energy security problem of the 1970's and 1980's. Over half Canada's oil consumption is for transportation fuels; most of the remainder is in the form of industrial boiler fuel, some power production, and the consumption of the petroleum industry itself.

Natural gas has increased in use and now accounts for 26% of the domestic demand for primary energy in Canada, but the pipeline system does not yet extend to the eastern provinces (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland). Coal, at one time a major energy source for Canada, is now limited to a small number of large, industrial users, mainly for steel-making and electricity production in some parts of the country. It has all but disappeared as a space heating fuel and is no longer widely used as a boiler fuel by industry.

Wood fuels continue to play an important role in both the residential and industrial sectors. Most of the wood fuel included in national energy statistics is in the industrial sector, and more specifically the pulp and paper industry, in which wood fuels, including spent pulping liquors, provide 50% of the industry's energy requirements. In some parts of the country, especially in Atlantic Canada and rural areas in Ontario and Quebec, wood provides a significant share of residential space heating. It is often used as a supplementary space heating fuel and the extent of its use is not precisely known because statistics on its use are not systematically collected and much of the trade in wood takes place in the informal economy.

Reference has already been made to the regional variation in primary electricity sources. Where available, hydropower has been the preferred alternative. Nuclear power has been developed in Ontario (20 large power reactors), where it now provides over half of the province's electricity; there are small programs (one reactor each) in Quebec and New Brunswick.

2 ENERGY EFFICIENCY TRENDS IN THE CANADIAN ECONOMY

In common with other OECD nations, the most significant new development in the Canadian energy economy in the past twenty years has been the dramatic improvement in energy productivity, measured as the ratio of Gross Domestic Product (GDP) to total domestic demand for primary energy. As shown in Figure A-8, after twenty years of relative stability, energy and economic growth in Canada began to "decouple". Between 1972 and 1992, the ratio of real GDP to domestic demand for primary energy increased by over 50% due to a combination of energy conservation and structural shifts in the Canadian economy toward less energy intensive outputs.

This overall improvement in the energy efficiency of the Canadian economy has contributed more to the nation's energy security over the past twenty years than all the new oil, gas, coal, nuclear and hydropower combined. More important in the context of this study, the improvement in energy efficiency of the Canadian economy has avoided the environmental stress from the expansion of energy supply that would have otherwise been necessary. Retrospective analysis of the energy productivity improvement[2] indicates that it has been about two thirds due to energy conservation

2. Ralph D. Torrie et. al., Energy Demand in Canada, 1973-1987: A Retrospective Analysis, prepared by Marbek Resource Consultants and Torrie Smith Associates in association with Diener and Associates and Statistics Canada for Energy Mines and Resources, March 1989.

and about one third due to structural changes in the economy, as illustrated in Figure A-9.

Perhaps of greatest significance to urban energy and environment issues is that the two thirds improvement from energy conservation was dominated by upgrades in the thermal efficiency of residential buildings and increases in the fuel efficiency of automobiles -- two of the largest components of urban energy use.

With respect to the automobile fuel efficiency gains, the Canadian auto industry is closely integrated with its American counterpart and Canadians benefited from the Corporate Average Fuel Economy (CAFE) standards implemented in the U.S. From 1978 to 1989, the average fuel consumption of new automobiles in Canada declined from 11.4 Litres/100 km to 8.1 L/100 km. The actual efficiency of the on-road fleet has declined from about 18 L/100 km in the early 1970's to about 11 L/100 km, enough to offset increased car ownership, growing population and higher levels of mobility. The efficiency of the on-road fleet will continue to improve for a few more years, although new car fuel economy improvements have levelled off. Although new cars with fuel economies of 5 L/100 km and less have been on the market for some years, the CAFE standards have not been increased for several years, real fuel prices have been falling, and there is some evidence that both driving habits and auto purchasing decisions are tending toward increased fuel consumption.

The other major story in Canadian energy efficiency improvement of direct relevance to urban energy use patterns is the improved thermal efficiency of housing. Figure A-10 shows the average annual space heating consumption of Canadian housing according to the period of construction.[3] The housing built in the 1970's and 1980's averages a little more than 500 MJ/m^2 per year, or about 80 GJ for a typical 160 m^2 Canadian house. This level of thermal efficiency is relatively high by international standards, and there are much more efficient designs that are in the first stages of commercialization. The government, utility and home building industry have cooperated in the design and marketing of a new model of resource efficient housing design which goes by the name of "R2000" and which requires about 40% less heating energy than typical new construction built to the national building code.[4] More than 75% of Canada's standing housing stock has been built since 1946, and more than 60% since 1961. The average thermal efficiency of Canadian housing is heavily dominated by the more energy-efficient construction techniques of recent years, will continue to

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3. Scanada Consultants Ltd., "Environmental Impact Study: Phase I -- Development of a Database on Housing Characteristics Representative of the Canadian Housing Stock", prepared for Research Division, Canada Mortgage and Housing Corporation, 682 Montreal Road, Ottawa, Ontario, K1A 0P7, 1992.

4. Marbek Resource Consultants Ltd., The Economically Attractive Potential for Energy Efficiency Gains in Canada -- Case Study #1, Residential Space Heating, with Torrie Smith Associates, WATSRF, and Peat Marwick Stevenson & Kellogg, for Energy Mines and Resources Canada, Ottawa, 1991.

improve as new housing goes up, and will accelerate with the take-up rates for the new generation of advanced designs (eg. R2000).

3 ENVIRONMENTAL STRESS FROM ENERGY PRODUCTION AND USE IN CANADA

As the preceding overview of Canadian energy supply and demand suggests, virtually all the different types of environmental stress associated with either the production or the consumption of fuels and electricity are present to a greater or lesser degree in Canada. Figure A-11 is a "spaghetti diagram" of the flow of energy resources and commodities in Canada. Energy analysts have used these types of diagrams for years to summarize in one picture a great deal of information about primary resource production, secondary end use consumption, imports and exports of energy commodities, and the flows and relations between them. But the figure can also serve as a framework for considering the many and various ways in which the technological energy system affects the environment. One can randomly select any point on this chart and find much to say about the interactions of the energy system and the environment at that point.

The social and environmental impacts of our energy use are so pervasive and far-reaching that it can be difficult to say where they begin and end. It is both a direct source of waste and pollution, and indirectly, a driving force of other types of unsustainable activities. Urbanization itself, for example, one of the most significant ecological aspects of human civilization, depends utterly on the technology of energy, on the ability to deliver large quantities of fuels and electricity to small geographical areas. Cities represent such a concentration of energy conversion that they glow bright on the infra-red photographs taken from outer space.

All the generic types of ecosystem stress are present in the technological energy system -- pollution loading, over-harvesting of renewable resources, extraction and depletion of nonrenewable resources and environmental restructuring.

- Air pollution from fuel burning is perhaps the most widely recognized environmental impact of the energy system, particularly in urban areas where the concentration of people (and fuel burning) often leads to severely degraded and unhealthy local air quality. In fact, fuel combustion is the leading source of the most serious local air pollutants -- nitrogen oxides, volatile organic compounds, sulphur dioxides, and particulate matter.

- Fuel combustion also releases carbon dioxide, which does not pose a local air quality threat, but does contribute to the global greenhouse effect, considered one of the most serious international environmental problems.

- The production of hydroelectricity is a leading cause of environmental restructuring in Canada. Although often described as an environmentally clean source of energy, hydroelectric development in Canada has resulted in enormous ecological damage, often totally transforming entire eco-regions in the course of massive river diversions.

- Nuclear power development has introduced a new class of energy-related pollutants in the form of the radioactive materials produced at various stages of the nuclear fuel chain, sometimes in extremely concentrated and volatile forms. These radioactive materials depend on technological systems for their perpetual containment.

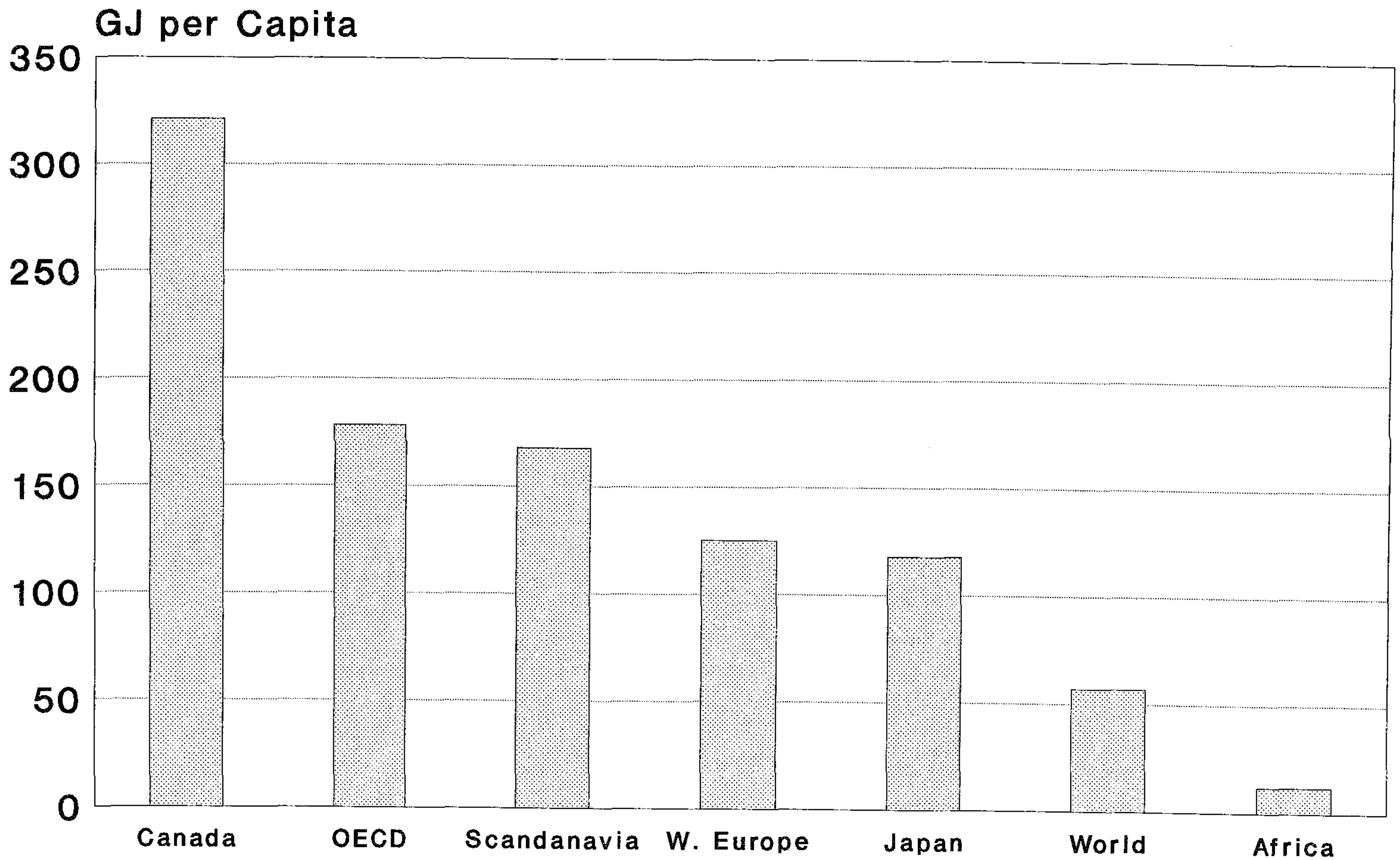
- The extraction of primary energy resources is a another major contributor to environmental stress in the form of non-renewable resource depletion, environmental restructuring, waste generation and pollution loading. In parts of western Canada, the primary energy resource industry (oil, gas, coal) represents the largest source of ecosystem stress.

- Above ground electric transmission lines, and oil and natural gas pipelines along with the right of ways and access corridors they require, constitute significant linear land uses in Canada, with associated environmental and aesthetic impacts.

- The environmental impact of automobiles bears particular emphasis in a discussion of urban energy and environment. The automobile and its associated infrastructure represents not only the largest direct source of environmental stress in urban areas (from tailpipe emissions) but also the largest indirect driving force behind many other types of ecosystem stress found in cities that result from the land use patterns and urban forms associated with high levels of automobile dependence.

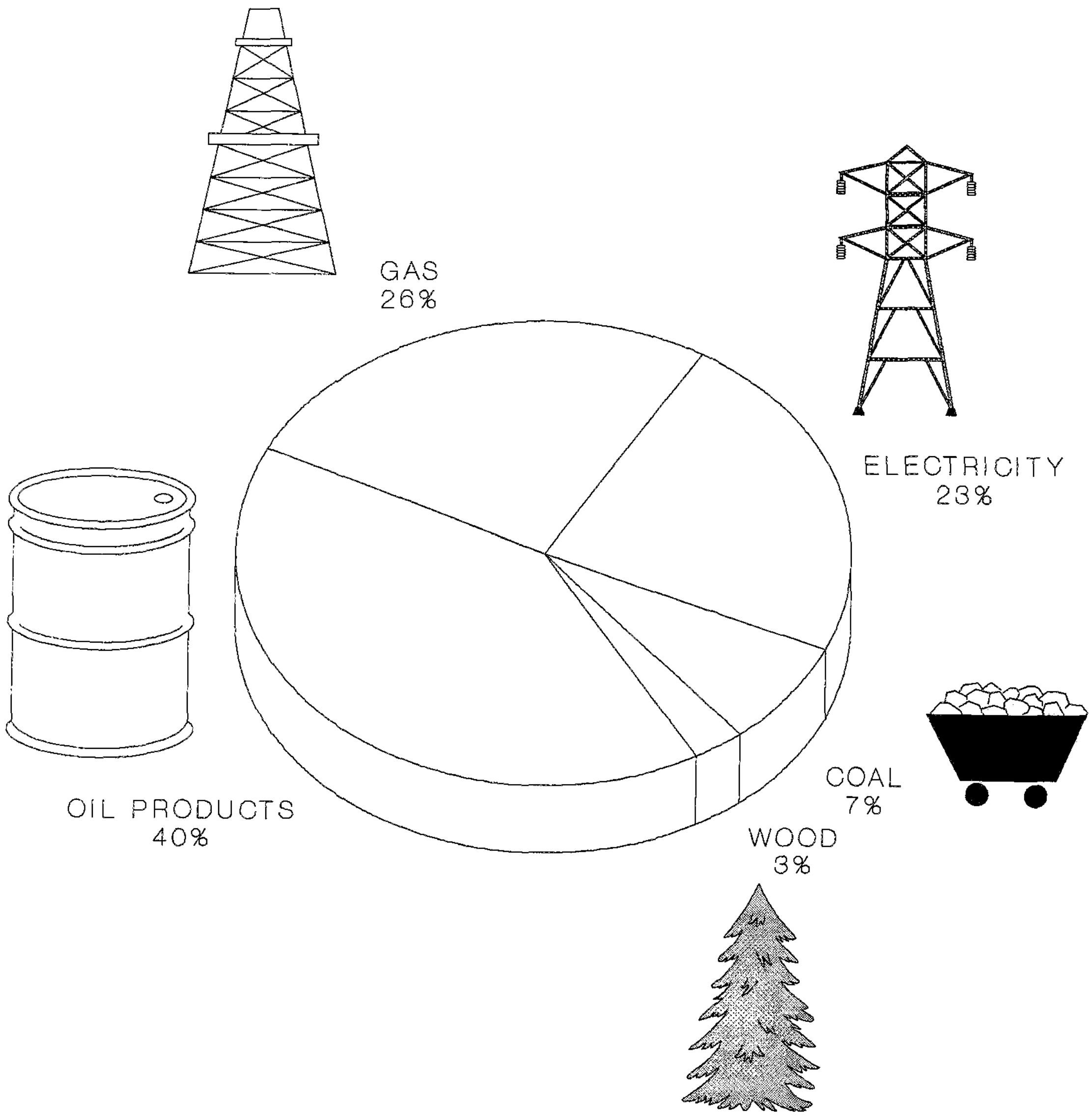
Certain of these environmental stresses from the energy system tend to be more immediately prevalent in cities, especially air pollution, but they are all at issue in a full discussion of urban energy management for environmental improvement. The final demand for energy services originates, for the most part, in cities, and so any gain from urban energy management that allows a particular task to be performed with less fuel or electricity will cause a reduction in environmental risk and ecological stress. This reduction in ecological stress occurs not only at the point of end use, but works its way "upstream" to the primary resource extraction, reducing environmental risk all along the way.

FIGURE A-1
PER CAPITA USE OF FUELS AND ELECTRICITY



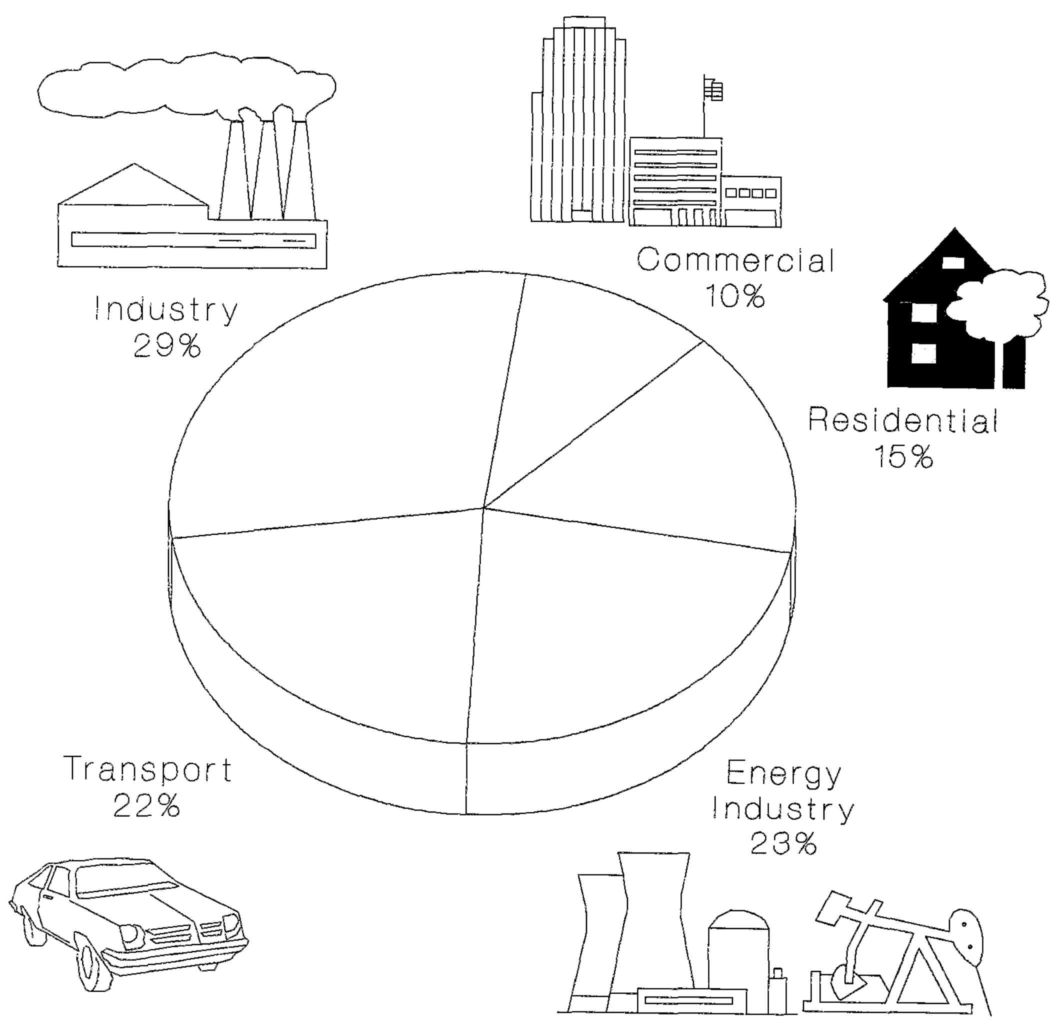
This data reflects total domestic demand for primary energy, which was about 8,700 PJ in Canada in 1992.

FIGURE A-2
ENERGY USE IN CANADA IN 1992, BY FUEL
(TOTAL: 8,735 PJ)



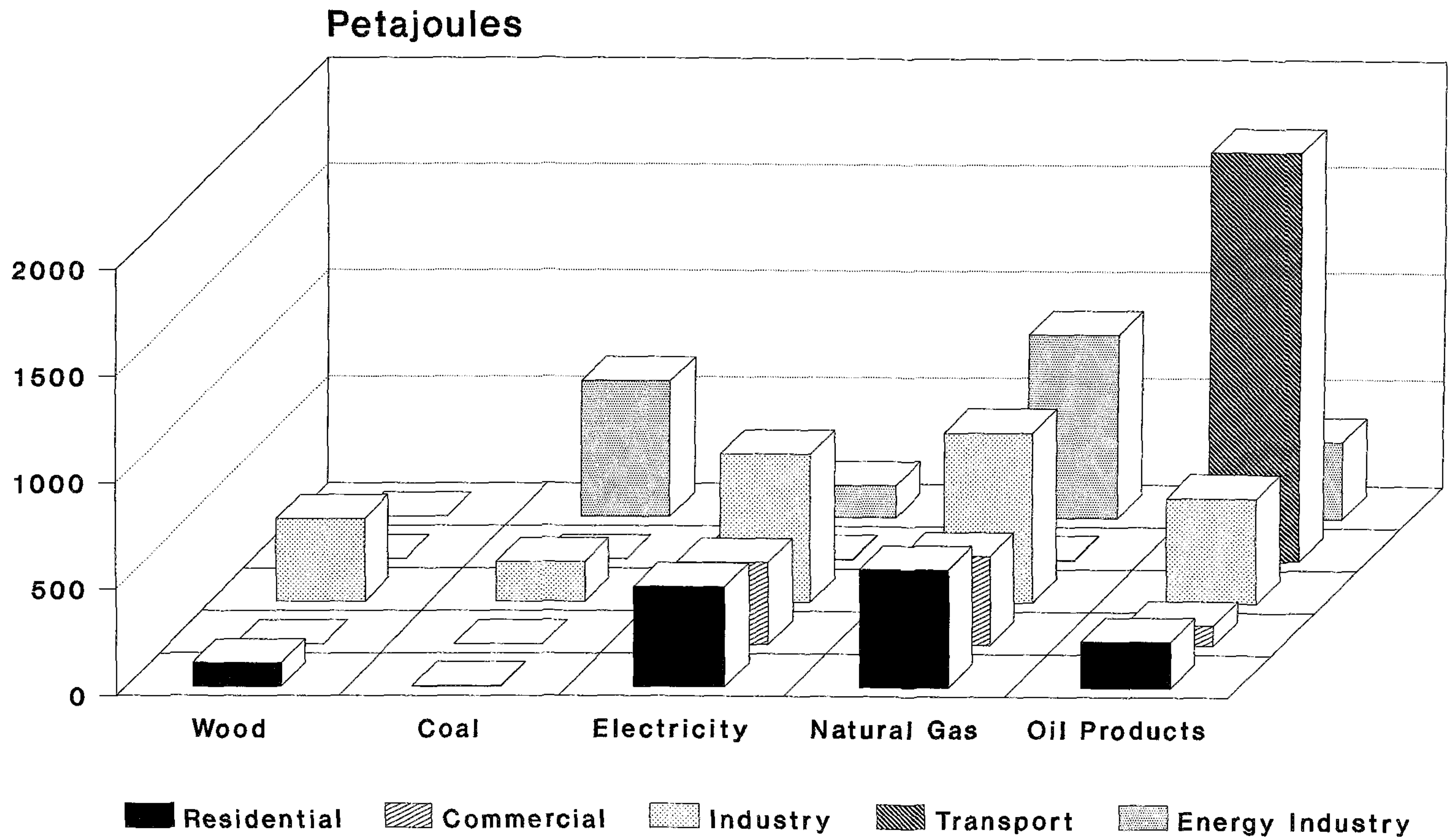
Thermal electricity counted as electricity; thermal power plant losses counted as fuel use.

FIGURE A-3
ENERGY USE IN CANADA, 1992, BY SECTOR
(TOTAL: 8,735 PJ)



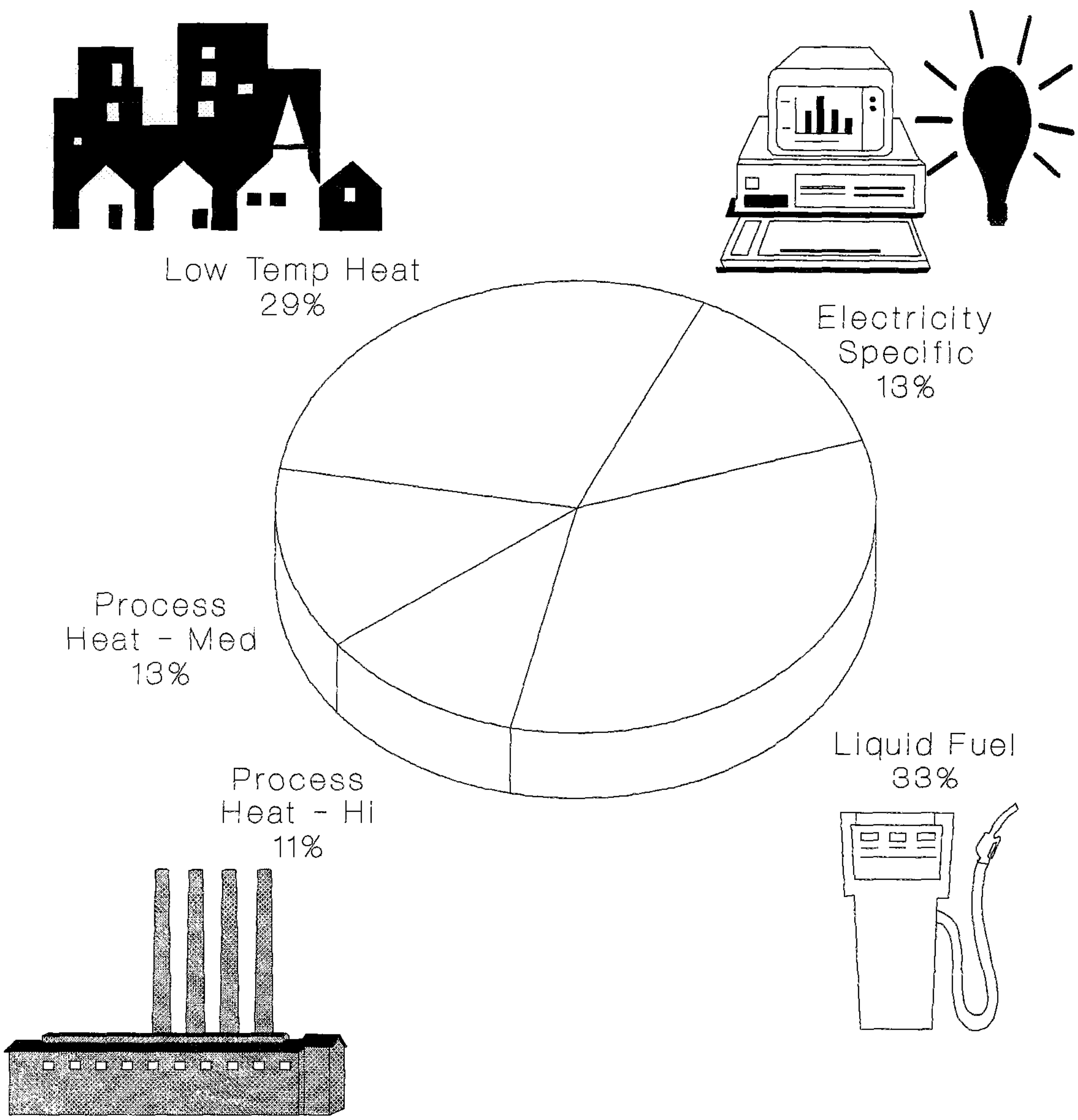
Energy industry includes power plant and transmission and distribution losses.

FIGURE A-4. FUELS AND ELECTRICITY USE IN CANADA IN 1992, BY CONSUMING SECTOR (Excluding exports and non-energy uses)



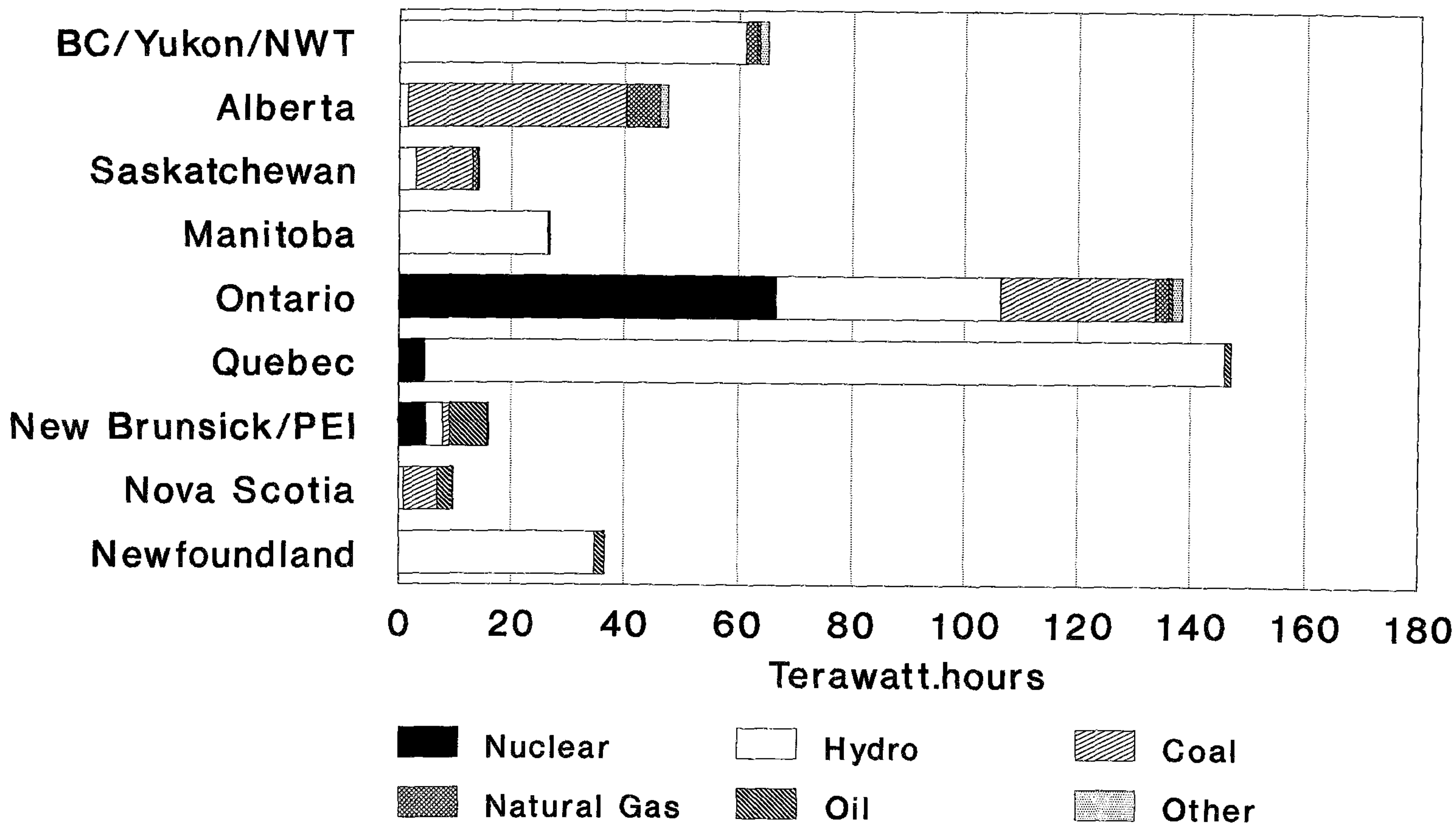
Source: Statistics Canada 57-003, 1992
Energy Industry includes thermal power plant losses.

FIGURE A-5. FINAL USE OF ENERGY IN CANADA, 1992, BY END USE, IN PJ (TOTAL: 6,726 PJ)



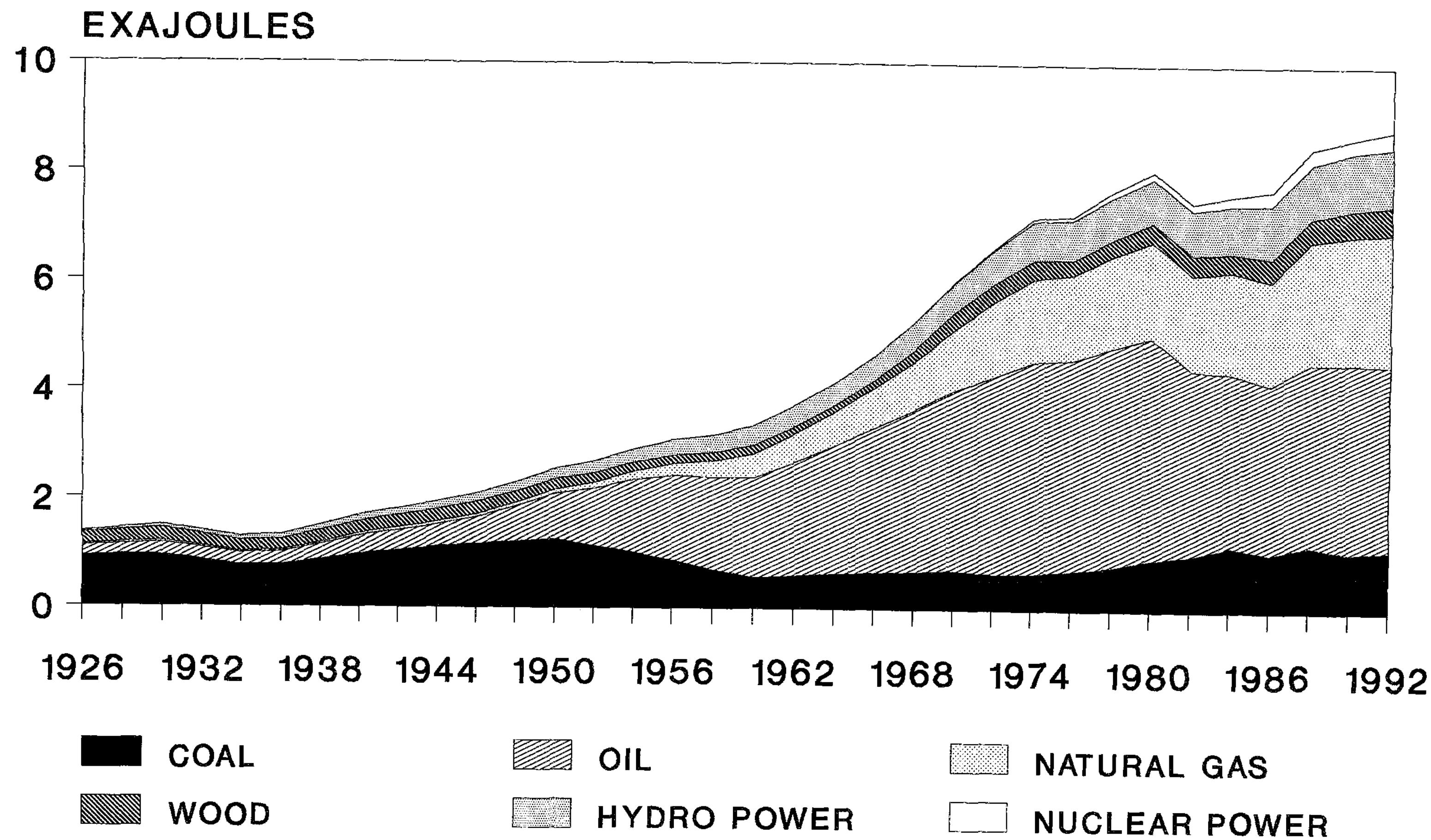
Final Demand, Net of Energy Industry
Source: Torrie Smith Database

FIGURE A-6
ELECTRICITY PRODUCTION BY PROVINCE, 1992



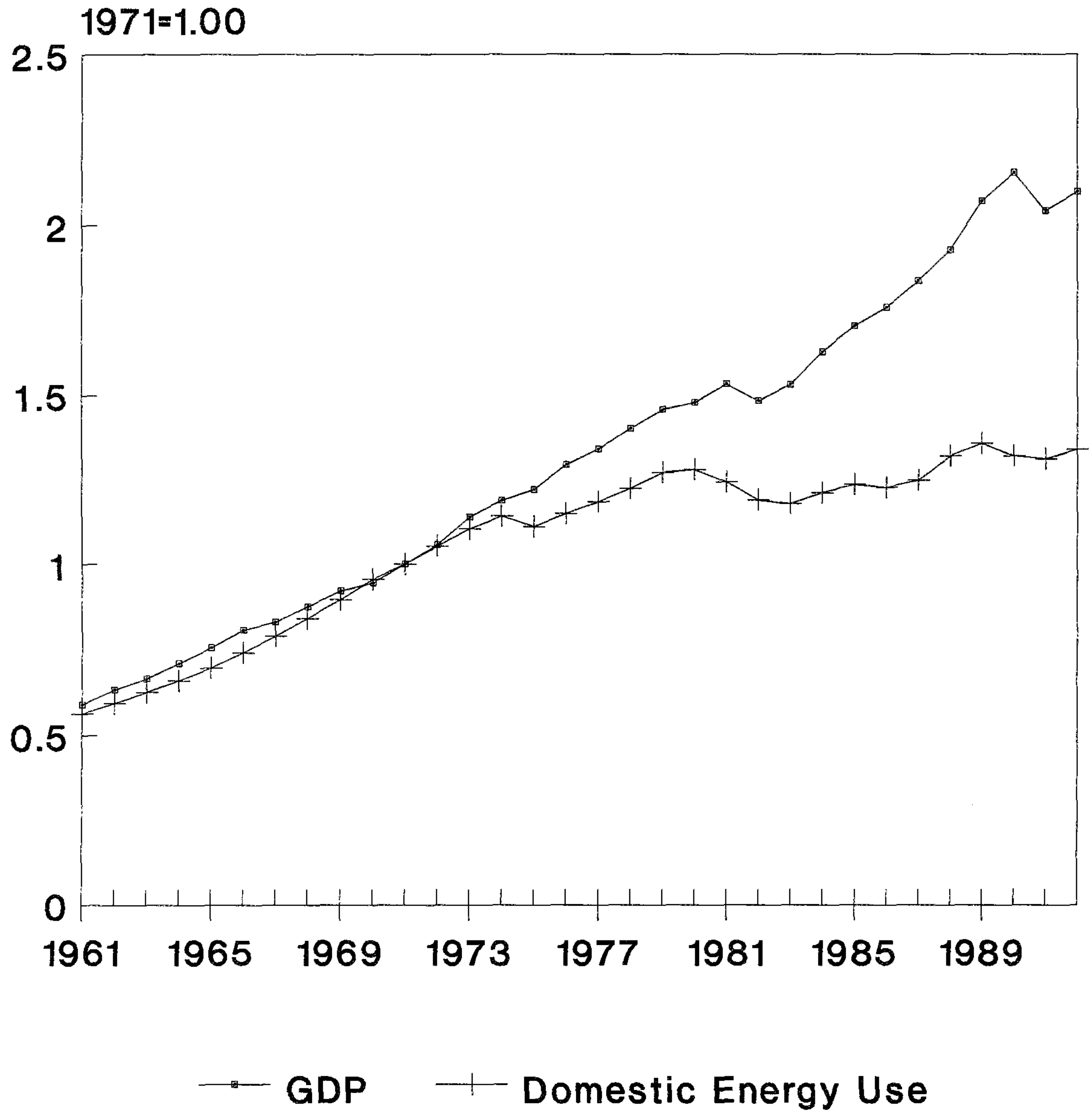
Source: Natural Resources Canada
Electric Power in Canada, 1992

FIGURE A-7. DOMESTIC DEMAND FOR PRIMARY ENERGY IN CANADA, 1926-1992



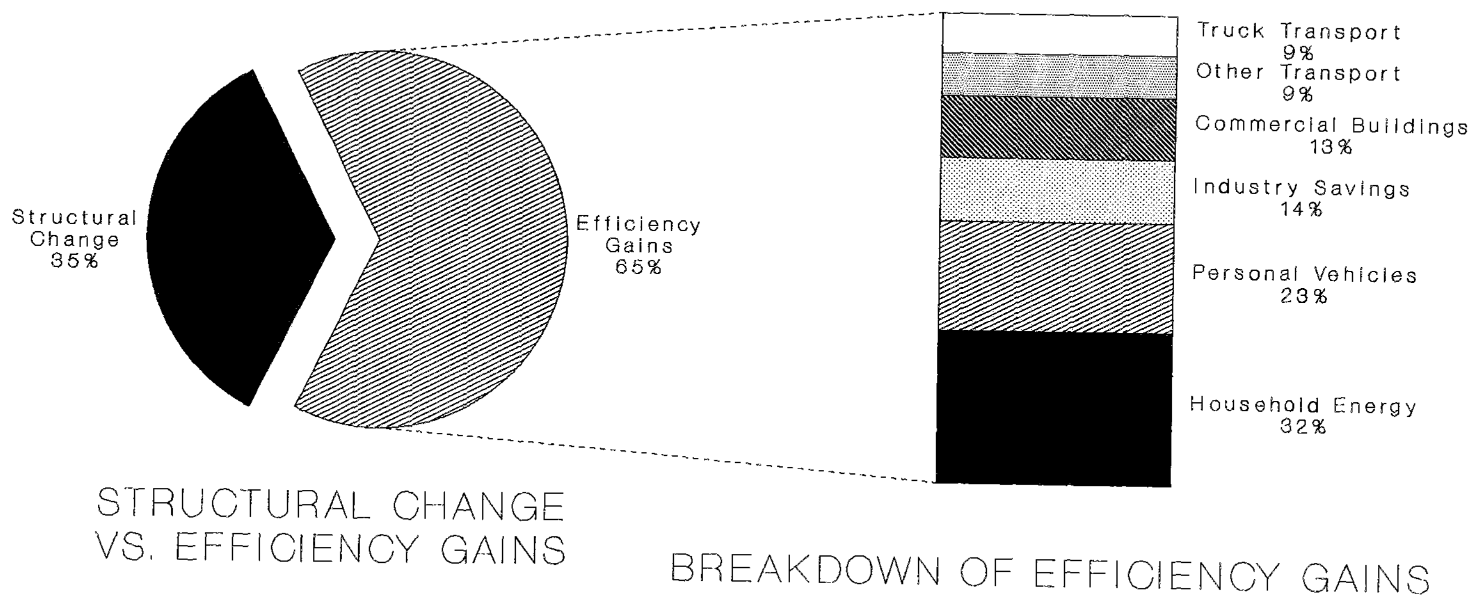
Nuclear and hydropower estimates represent actual power plant output

FIGURE A-8. RELATIVE GROWTH OF GROSS DOMESTIC PRODUCT AND ENERGY DEMAND IN CANADA, 1961-1992



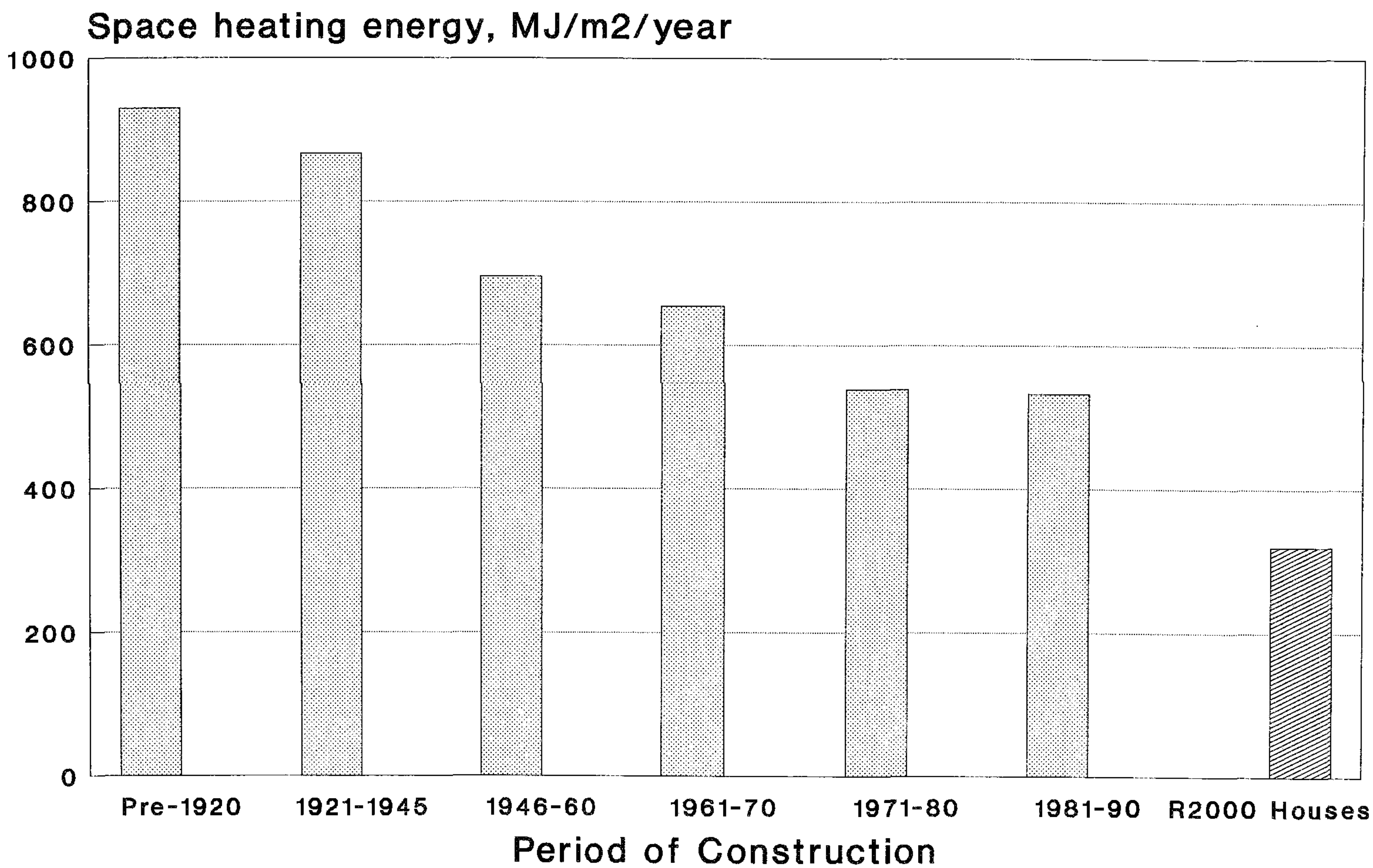
Source: Canadian Economic Observer, Statistics Canada 57-003, Torrie-Smith Database

FIGURE A-9
CONTRIBUTIONS TO DECLINE IN ENERGY/GDP RATIO IN CANADA, 1971-1988



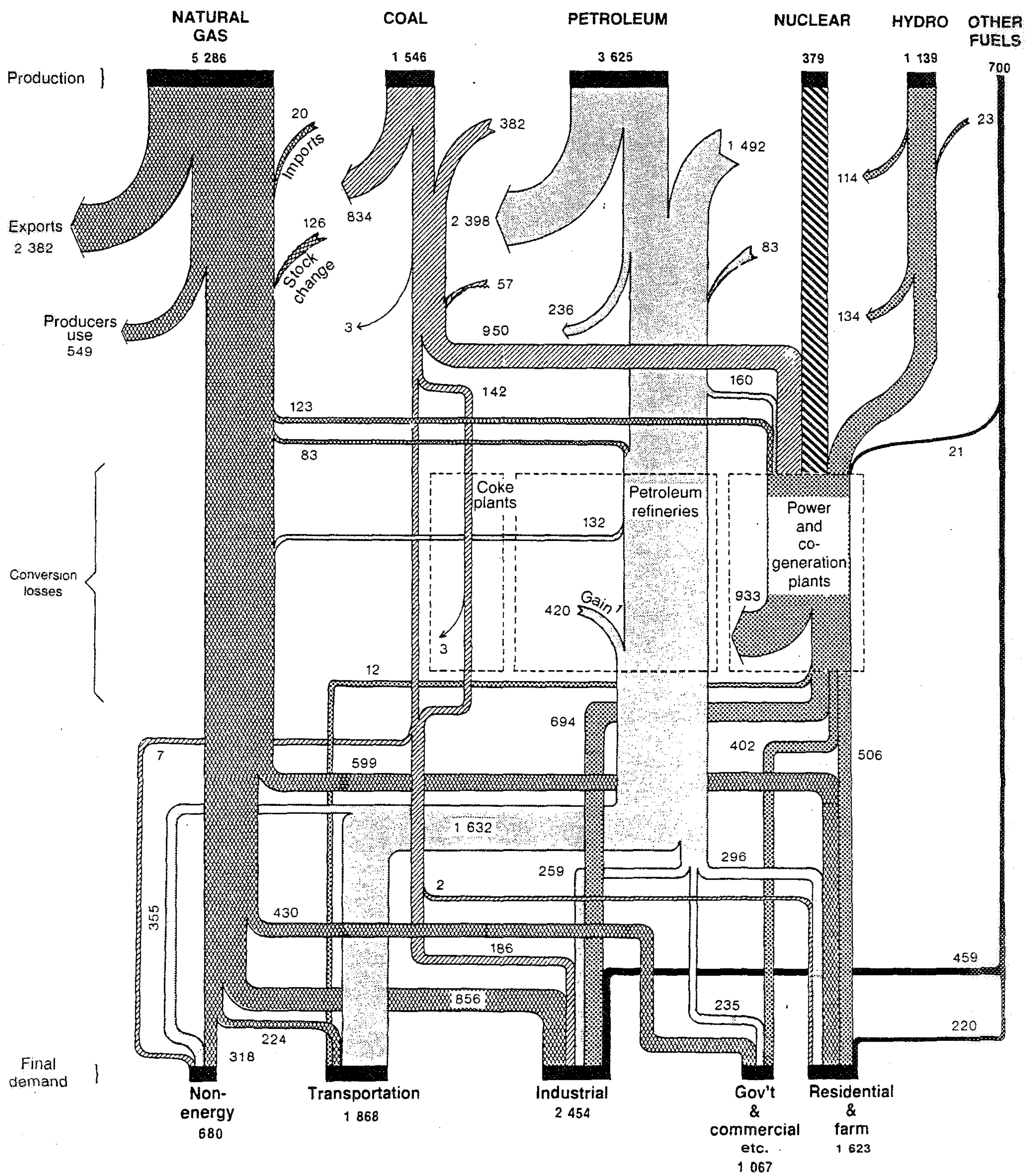
Source: Torrie Smith Assoc. Database

FIGURE A-10
AVERAGE ANNUAL SPACE HEATING CONSUMPTION OF CANADIAN HOUSES (MJ/m2/year)



Source: Scanada/CMHC, 1992.

FIGURE A-11 CANADIAN ENERGY FLOW CHART*
1992 (petajoules)



* data modified for charting purposes
[1] gain due to method of conversion used

Source: Statistics Canada, Cat. 57-003, 1992.

APPENDIX B

City of Ottawa
Task Force on the Atmosphere
February 21, 1994

LONG LIST OF CO_2 REDUCTION MEASURES

The following list is based on one created by Ralph Torrie for the International Council on Local Environmental Initiatives and will serve as a starting point for discussion. The measures have been separated by sector, then by end-use.

RESIDENTIAL

END USE: Space Heat

Category	Specific Measures
Improve thermal efficiency of building envelope	Add insulation to walls, roof and floor High efficiency windows, low emissivity, double paned Design to optimize use of passive solar
Improve the air tightness of the building envelope	Weatherstripping, caulking
Increase the efficiency of the heating system	High efficiency burners Resized and high efficiency furnace fan motors Air sealing of ducting systems Optimization of duct diameters and energy efficiency of ducting system design
Reduce the heating/cooling energy required	Night setback of temperature in heating season; programmable thermostats Reduce demand through operation and maintenance guidelines, education etc. Tree planting for wind breaks and summer shade Canopy shades
Increase the efficiency of the cooling system	High efficiency cooling technology Water spray cooling
Switch to a less carbon intensive fuel	Increased use of district heating Switch from coal to oil to gas to low carbon electricity to low carbon district heating to solar

END USE: Water Heat

Category	Specific Measures
Increase the efficiency of the water heating system	High efficiency burner; electronic ignition
Reduce thermal losses from the water heating system	Insulate water tank and pipes Install valves to reduce standing losses
Switch to renewable or less carbon intensive energy form	Solar water heating technology
Reduce the temperature of the hot water delivered to the end use	Thermostat setback; programmable thermostats, timed thermostats Education on efficiency of hot water use; appropriate temperature settings etc.
Decrease the demand for hot water	Low flow showerheads Point of use heating technology Water efficiency dishwashers Cold water laundry Water efficient faucets

END USE: Residential Appliances

Category	Specific Measures
Increase the efficiency of the appliance	High efficiency refrigerators High efficiency, horizontal axis clothes washers Bi-radiant and induction cooktop technologies for cooking; gas stoves with infrared burners High efficiency appliances of various sorts
Switch to a less carbon intensive fuel	Gas cooking and clothes drying where electricity is carbon intensive
Reduce appliance ownership and use	Education

END USE: Lighting

Category	Specific Measures
Reduce lighting demand	Education; lower wattage bulbs, lights off when not needed etc. Occupancy sensors
Increase efficiency of lighting technology	Compact fluorescent lights

COMMERCIAL SECTOR

END USE: Water Heat (see Residential)

END USE: Heating & Cooling

Category	Specific Measures
Increase the energy efficiency of the HVAC systems	Air and water balancing Resized and high efficiency motors for fans and pumps Variable speed drives on fan and pump motors Variable air volume design Install economizer where not already present Continuous reset of air supply temperature Resize and install high efficiency chillers Resize boiler and replace with condensing boiler Air sealing of ducting systems Optimization of duct diameters
Increase the thermal efficiency of the building envelope	Increased insulation in walls, roof, basement Design optimization; esp. window area, materials, coating, etc. High efficiency, low emissivity windows
Reduce the internally generated heating and cooling loads	Implement energy efficiency improvements in all energy using equipment inside envelope
Increase the air tightness of the building envelope	Weatherstripping, caulking

END USE: Lighting

Category	Specific Measures
Reduce the amount of light being provided	Delamping; task lighting Design for optimal use of daylighting, integrate with photosensors and control systems, occupancy sensors
Improve the efficiency of the lighting systems	High efficiency lamps, dimmable electronic ballasts, specular reflectors, occupancy and daylighting sensors and controls Compact fluorescent replacements for incandescent bulbs

END USE: Plug Load

Category	Specific Measures
Reduce intensity of plug load applications	Education; off when not in use, etc.
Increase energy efficiency of plug load technology	Energy efficient computers, photocopiers, laser printers, etc. Install high efficiency power supplies and power management software for computers, printers and copiers

END USE: Refrigeration

Category	Specific Measures
Increase energy efficiency of refrigeration technology	Replace existing compressors in refrigeration systems with high efficiency compressors Install variable speed drives on refrigeration compressors to optimize motor speed Install high efficiency fan motors on refrigeration evaporators
Reduce demand for refrigeration	Install covers and doors on retail displays Optimize temperature

TRANSPORTATION

END USE: Transportation of people (person-kilometres)

Category	Specific Measures
Reduce demand for person-kilometres	Urban planning to reduce origin-destination distance: increase development density; intensify development; integrate land uses; take advantage of solar access Telecommuting Shortened work week
Increase occupancy rates of vehicles	High occupancy vehicle lands Car pooling Price and tax mechanism
Increase fuel efficiency of passenger vehicles, especially cars	Combination of technological improvements; emphasis on efficiency under urban driving conditions i.e. low speed Policy and program initiatives to accelerate stock turnover
Switch to less carbon intensive fuels	Alcohol fuels, perhaps hydrogen or electricity, depending on primary source and time of charging
Increase transit modal share	Pricing and tax policies, promotion and education, intensify transit network and service
Increase overall fuel efficiency of personal transportation	Traffic planning measures to minimize fuel consumption

END USE: Transportation of goods (tonne-kilometres)

Category	Specific Measures
Reduce the demand for tonne-kilometres	Consumption reduction; encourage consumption of local products
Improve the fuel efficiency of freight transportation	Computerized scheduling and planning of vehicle use Fuel efficient trucks and other freight carrying vehicles Education and coercive measures to reduce idling and increase fuel efficiency of driving patterns of delivery vehicles

INDUSTRY

END USE: Process Heat and Electrolysis

Category	Specific Measures
Increase the efficiency of process heat generation and delivery	Pipe insulation Boiler controls and efficient burner technology
Reduce the demand for process heat	Heat recovery and reuse technologies of various sorts
Switch to less carbon intensive fuel	As above

END USE: Motive Power

Category	Specific Measures
Increase the energy efficiency of motive power systems	Industrial cogeneration systems Variable speed drives on industrial motors
Reduce the demand for motive power	Production system design for optimization
Switch to less carbon intensive fuels	

UTILITIES

Utility	Category	Specific Measures
Water and sewage treatment	Reduce pumping requirements	Water conservation measures and technologies
	Increase efficiency of pumping systems	High efficiency motors Variable speed drives
Streetlighting	Reduce lighting requirements	Photosensor controls, timers
	Increase efficiency of lighting	High and low pressure sodium; high intensity discharge Reflectors, energy efficiency ballasts
Power Generation	Repowering plants	More efficient generation technologies(e.g. fluidized bed)
	Switch to less carbon intensive fuels	Select use of natural gas Industrial cogeneration
	Renewable energy	Photovoltaics; wood fired generation; wind power Methane power plants from organic waste