RESEARCH HIGHLIGHTS

Socio-Economic Series Issue 50 - Revision II

GREENHOUSE GAS EMISSIONS FROM URBAN TRAVEL: TOOL FOR EVALUATING NEIGHBOURHOOD SUSTAINABILITY

Introduction

As a result of the Kyoto Summit in December 1997, the federal government is developing strategies to reduce greenhouse gas (GHG) emissions in Canada. A key challenge to reaching this goal is urban transportation, which is a major and growing contributor to GHG emissions in Canada. This is largely due to increasing levels of private automobile use together with declining rates of public transit use in most Canadian cities during the past decade.

Many studies demonstrate that there is a strong link between automobile ownership and use and the way communities are planned. To date, little work has been done on quantifying the reductions in transportation energy consumption and emissions that result from alternative development scenarios.

Objectives

This study develops a model of GHG emissions from personal urban transportation given variations in neighbourhood characteristics, including community and housing design, socio-economic makeup, and locational factors. The results provide valuable insight into how communities can be designed and planned to reduce GHG emissions from passenger travel in urban areas.

The main purpose of the study is to develop a user-friendly quantitative tool to make the mathematical model easy to use in evaluating development proposals in terms of GHG emissions. The user inputs data on the characteristics of the neighbourhood and the tool forecasts the annual per-household GHG emissions from transportation. In this study, the results supplied by the tool are used in discussing the sustainability of nine neighbourhood scenarios that embody a wide range of contrasting locational and neighbourhood design characteristics.

Modelling Approach

Data on vehicle ownership, automobile vehicle-km of travel (VKT), and passenger-km of travel on public transit (PKT) per household in the Greater Toronto Area (GTA) were obtained from the 1996 Transportation Tomorrow Survey (TTS). This rich data set is based on a sample of 115,000 households (a 5 per cent sample) in the GTA. The traffic zone level of aggregation was chosen for the basis of analysis, as this provides a convenient means for summarizing travel data and is also compatible with the need to make comparisons at the neighbourhood level. The analysis was limited to traffic zones within the Toronto Census Metropolitan Area (CMA) and to traffic zones with a minimum number of responding households. The final data set for model calibration retained 795 traffic zones. Data on the individual variables that may have an effect on household travel behaviour were obtained from a variety of sources, including the TTS, Census data, and data derived from geographic information systems.

It was important initially to gain a thorough understanding of the individual potential explanatory variables. To this end, univariate analyses of the individual variable's impact on auto VKT per household were carried out. The primary modelling approach in this study was to develop separate sub-models of vehicle ownership, weekday auto VKT, and weekday transit PKT per household using multivariate regression analysis. Multivariate regression makes it possible to examine how a single dependent variable (e.g. VKT/household) is affected by the values of one or more independent variables.

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Findings

Key Variables Influencing Auto Use and GHG Emissions

The results of the multivariate analysis reveal a number of insights about the effect of different neighbourhood characteristics on household vehicle ownership and auto and transit travel intensity. Overall, socio-economic and locational variables tend to have a stronger influence than neighbourhood design variables.

Socio-Economic Variables:

- The variable with the strongest influence on auto VKT was the number of vehicles per household.
- To a lesser extent, the number of people in the household also strongly influences VKT; the number of people per household is the strongest predictor of PKT.
- The average number of adults per household is the strongest predictor of auto ownership per household.
- Household employment income was the second most important indicator of household vehicle ownership, whereas individual worker income seems to be a better predictor of auto VKT than household income. As income increases, auto use and ownership increases.

Locational Variables:

- Distance to the Central Business District (CBD) has a strong influence in all three sub-models. This is the second strongest explanatory variable,
  after vehicle ownership, in the auto VKT model. The model parameters suggest that, for every kilometre a household moves away from the CBD, weekday VKT per household increases by approximately 1.0 km.
- An increase in the number of jobs within a 5-km radius of the neighbourhood centroid can greatly reduce auto VKT per household as can a high degree of land-use mixing (i.e. combining residential uses and jobs in an area).
- Increasing local transit-vehicle-service hours tends to reduce household vehicle ownership and increase transit PKT per household. Having close access to a rapid transit station slightly decreases auto ownership levels and VKT per household.

Neighbourhood Design Variables:

- An increase in housing density (the number of housing units within a 1-km radius of the neighbourhood centroid) moderately decreases vehicle ownership and increases transit travel.
- A high degree of mixing structural housing types in a neighbourhood can slightly reduce auto ownership, while increasing the average size of a neighbourhood's housing units (in rooms/unit) can slightly increase auto ownership levels.
- Neighbourhoods with a curvilinear road layout tend to have slightly increased auto ownership levels; those with a rural grid road type have slightly higher auto VKT levels, all else being equal.
- An increase in the number of intersections per road-km in a neighbourhood slightly reduces auto VKT, presumably because it improves connectivity for walking and cycling trips.
- Increasing neighbourhood employment moderately reduces household transit PKT.
- The presence of local shopping opportunities slightly reduces household auto ownership levels and reduces transit PKT and has an indirect moderating influence on auto VKT levels and GHG emissions.
- The presence of wide arterial roads either within the neighbourhood or on its periphery, slightly increases auto use.
- The presence of bike lanes and recreational paths slightly reduces auto use.

Appropriate factors were applied to predicted values of weekday auto VKT and weekday transit VKT to calculate annual GHG emissions. The final models, based on the multivariate regression approach, were incorporated into an **easy-to-use spreadsheet tool**. All of the variables described above can be manipulated by a user of the tool to test a variety of development proposals in terms of GHG emissions from personal travel. The tool is capable of establishing the relative difference between 2 or more neighbourhoods in any large metropolitan area, although the absolute GHG estimates may not be exact.

Neighbourhood and Urban Context Scenarios

Nine contrasting neighbourhood scenarios were subjected to analysis using the model executed within the spreadsheet tool. These nine neighbourhoods are combinations of the three neighbourhood designs and three urban contexts. The three urban context scenarios generally correspond well to the Inner Area, Inner Suburbs, and Outer Suburbs of the Toronto Census Metropolitan Area. These are located 5 km, 10 km, and 30 km from the Central Business District, respectively, and have varying access to employment and transit.

The neighbourhood design concepts are as follows:

- **Neighbourhood 1: Conventional Suburban-Type Development** - This neighbourhood concept reflects the characteristics of modern suburban developments, with typical low-density single-use residential patterns. Streets generally consist of curves and cul-de-sacs extending out to wide auto-oriented arterial roadways.
- **Neighbourhood 2: Medium-Density Development** - This neighbourhood concept tends to have a mix of single detached houses on medium-sized lots, low rise townhouses, and mid-rise residential apartment buildings. Such neighbourhoods typically have a higher number of persons than jobs, but still have significant opportunities for self-containment in terms of local employment. The road layout is mainly curvilinear, but with some continuity and connectivity for transit vehicles and pedestrians.
- **Neighbourhood 3: Neo-Traditional Development** – This neighbourhood concept represents a return to communities that are more "friendly" to pedestrians, bicyclists, and transit users. The road layout type is generally a grid pattern of closely spaced streets with full accessibility to adjacent arterials. Such neighbourhoods have a mix of housing typologies including apartment buildings and closely spaced housing units. There is a much greater presence of non-residential uses (grocery stores, retail shops, schools, and employment complexes) in this neighbourhood concept than in the first two neighbourhoods.

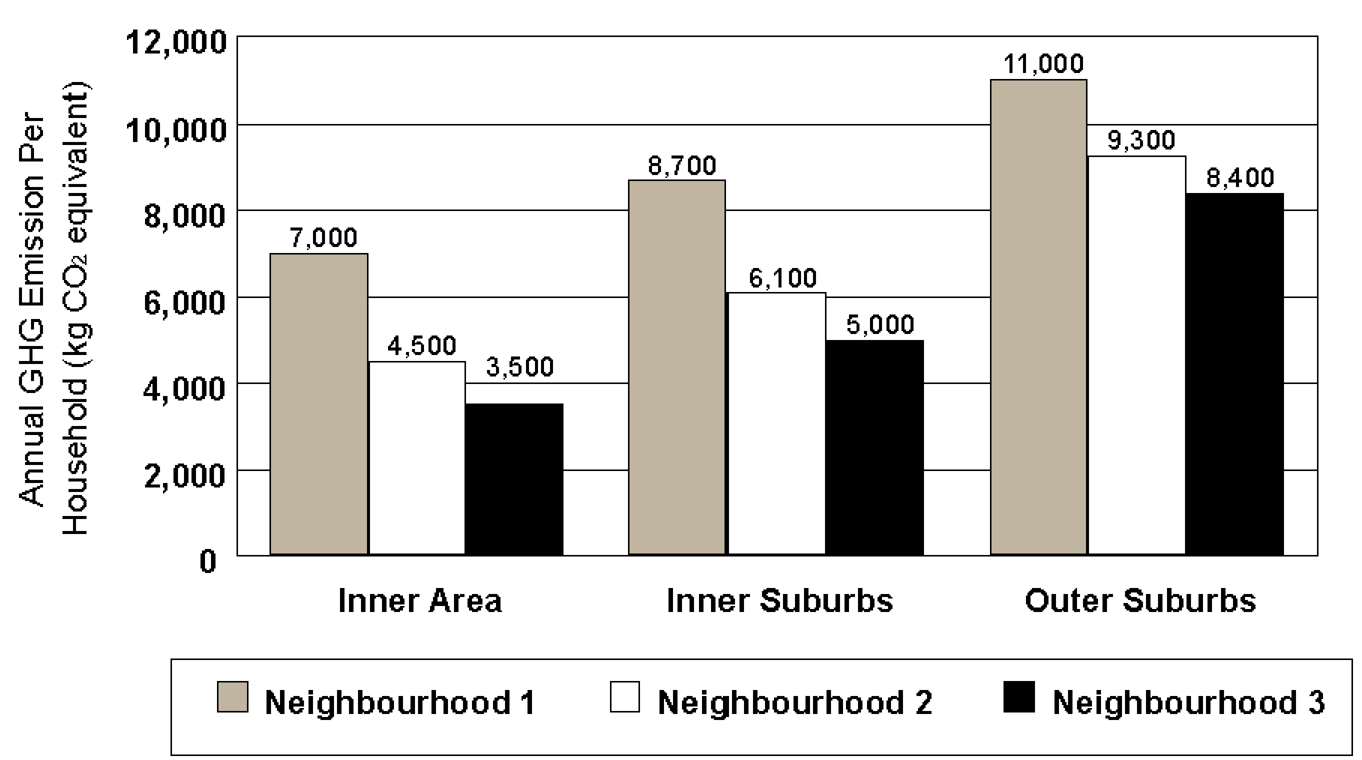
Figure 1 shows graphically the annual GHG emissions for the nine different neighbourhoods as predicted by the model, making it easy to see that both the urban context and the neighbourhood design context have a significant effect on GHG emissions from travel. However, it is valuable to note the relative influences of locational and neighbourhood design variables. Changing the neighbourhood context from the Outer Suburbs to the Inner Area decreases GHG emissions by 36 per cent to 60 per cent for the various neighbourhoods, whereas keeping the urban context the same and adopting the compact, mixed-use, pedestrian-oriented design decreases GHG emissions 24 per cent, to 50 per cent. As a result, neighbourhoods with neo-traditional neighbourhood designs located in the Outer Suburbs produce more GHGs than the neighbourhood with land-intensive suburban-type design located in the Inner Area. The former neighbourhood generates about 20 per cent more annual GHG emissions from travel than the latter.

Conclusions

This study resulted in the development of a model that is able to explain a substantial amount of the interaction between neighbourhood characteristics and vehicle use. The R^2 values for the auto VKT and auto ownership models are quite good, at 0.836 and 0.877, respectively, whereas the R^2 for the transit model is only a moderate 0.327.

The results of the evaluation of the nine neighbourhood scenarios

Figure 1:
Neighbourhood Scenarios' Annual GHG Travel Emissions per Household



using the model developed in this study suggest that the "macro" urban structure is more important than the "micro" neighbourhood design in reducing GHG emissions from auto and transit travel by neighbourhood residents. That is, infill development to increase resident population in inner areas and inner suburbs is more effective than greenfield development in moderating the growth of GHG emissions, even if the new greenfield neighbourhood is neo-traditional rather than typical auto-dependent/suburban in design. However, neighbourhood design is also a significant determinant of GHG emissions and can go a long way in improving the sustainability of neighbourhoods in the outer regions of urban areas.

The spreadsheet tool produced by this study provides a useful instrument for planners and developers in estimating the GHG emissions implications of both neighbourhood design and the broader-scale urban structure considerations of infill versus greenfields development.

Project Manager: Susan Fisher

Project report: Greenhouse Gas Emissions from Urban Travel: Tool for Evaluating Neighbourhood Sustainability, 2000

Project Consultants: IBI Group

A full report on this project will be available from the Canadian Housing Information Centre at the address below.

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