Quick Analysis Technique to Estimate GHG Emissions Based on Neighbourhood Built Form
Méthode d’analyse pour estimer les émissions de GES en fonction de la forme urbaine

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Abstract

- There is growing awareness of climate change and its potential impacts. In response, many municipalities and provinces have set greenhouse gas (GHG) emission reduction targets. The transportation sector is one of the largest contributors to Canadian GHGs. As such, it will increasingly be called upon to help achieve GHG emission reductions. In the past few years, considerable research and policy in the transport sector has focused on reducing GHG emissions through improvements in technology, fuels and vehicles. However, there has been less attention given to travel activity. There are even fewer studies looking at how to reduce automobile usage and distances travelled, and especially less work investigating the relationship between built form (suburban vs. urban, type of infrastructure, etc.) and its impact on automobile usage.

- **This study focuses on transportation related GHG emissions by examining the association between built form and travel activity.** The objective is to present a quick-analysis tool to **assess the GHG impacts** based on changes in vehicle kilometers travelled (VKT): **built form** (density, mixed-uses, etc.), **infrastructu**re (street connectivity, distance to high order transit, sidewalks, etc.) and **context** (location in region, demographics, TDM, etc.). This tool was developed to identify the most efficient improvement methods in a suburban context, without the need to develop an extensive travel activity model.

- This relationship is shown through the **development of multiple scenarios to compare and contrast the GHG emissions of neighbourhoods with different characteristics** (built form, infrastructure, regional context, etc.). Existing research on travel behaviour and the built form is used to analyse the relationship between the vehicle-kilometres driven by residents and the built form and regional context of a neighbourhood. This method is used to examine the effects of improving street grid connectivity, sidewalk coverage, cycling infrastructure and transit service areas on GHG emissions, for each neighbourhood scenario. In turn, this information provides a useful decision-support tool that enables toidentify the most effective strategies for reducing GHG emissions in existing and new neighbourhoods, while taking into account the local and regional context.

Link Between Built Form, Transportation Infrastructure, Travel and GHG Emissions

- Factors influencing transport GHG Emissions

GHG emissions = Distance travelled (VKT) x Vehicle emissions per km x Factor (traffic conditions)

Modal Share

Distance travelled by car

Number of car trips

Factors influencing distances travelled

- Numerous built form, regional, individual and trip factors influence travel decisions

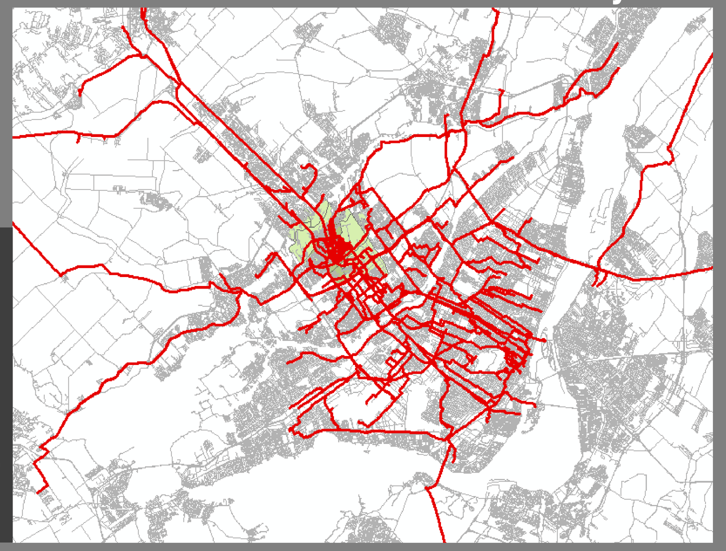
Regional	Neighbourhood Design	Individual	Trip
• Location of neighbourhood • Regional structure • Structure of transport networks • Accessibility to jobs and retail	• Population density • Mixed-use • Street grid connectivity • Proximity to local services and shops • Transit (proximity and quality of service) • Presence of pedestrian and cycling infrastructure	• Age • Sex • Self-selection of households • Occupation • Revenue • Access to a vehicle • Tolerance (cost, comfort, etc.)	• Motive • Time of day • Cost • Constraints • Trip chaining • Trip frequency

General Methodology to Estimate Vehicle Kilometers Travelled (VKT) Impacts of Built Form and Transportation Measures

- Neighbourhoods can be identified based on regional attributes (see regional factors in table below)
- Four step method :
  - 1) Establish baseline vehicle-kilometres travelled in the study area
  - 2) Identify opportunities and constraints for interventions in the neighbourhood
  - 3) Assess the effectiveness of different measures and scenarios on total VKT
  - 4) Identify and assess the effectiveness of measures

1) Establish baseline vehicle-kilometres travelled in the study area

Car-driver itineraries for a suburban neighbourhood in the Montreal area during a typical workday (19.0 km per capita per day or 5.1 kg CO2 equ.)



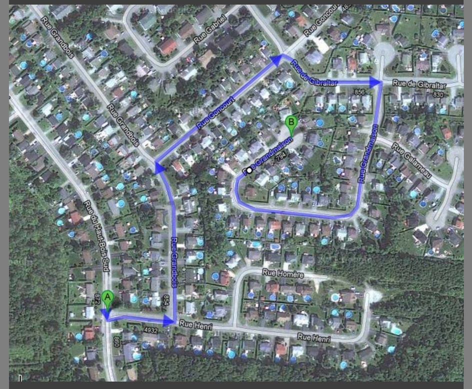
2) Identify opportunities and constraints for interventions in the neighbourhood and assessing current conditions (examples)

- **Street Grid Connectivity**

Orthogonal street grid

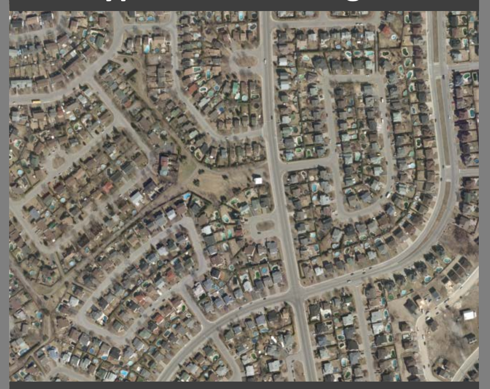
4.8 intersections/km
63% 4-way intersections

Grid with dead-ends



3.7 intersections/km
12% 4-way intersections

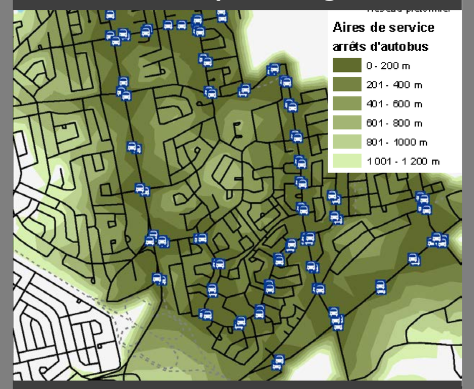
Typical suburban grid



4.3 intersections/km
17% 4-way intersections

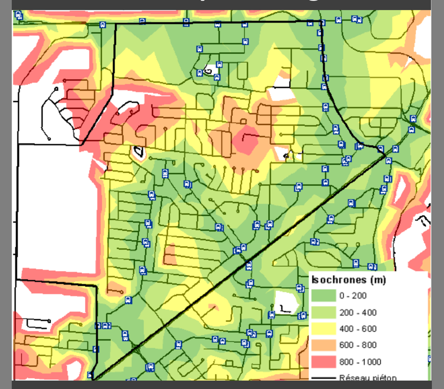
- **Bus-Stop Service Areas and Walking Distances to Stores**
- Suburban street grids increase access distances to these services, often due to poor connectivity to arterials

Bus Stop Coverage



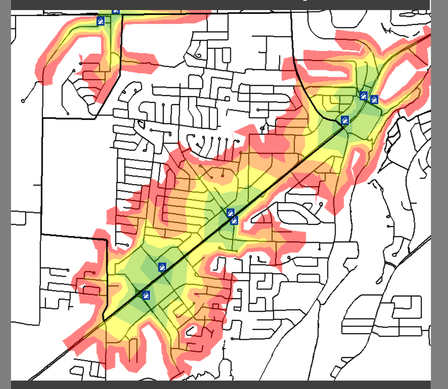
66% of residents within 400m

Bus Stop Coverage



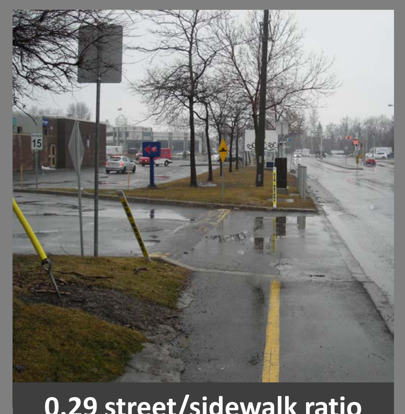
71% of residents within 400m

Distance to shops



35% of residents within 800m

- **Active transportation (pedestrians and cyclists)**



0.29 street/sidewalk ratio
(2.0 = sidewalks on both sides throughout)

0.08 street/sidewalk ratio
Little continuity

Good internal cycling connectivity, but few external cycling links

3) Assess the effectiveness of different measures and scenarios on total VKT travelled

- Evaluation based on existing indicators (connectivity, coverage, level of transit service, active transport infrastructure and land use)
- Based on the identification of constraints, improvements to connectivity were identified and their impacts assessed using elasticity factors based on literature
- Little individual effect of measure, but much greater when combined

Elasticity factors of VKT of selected measures

Type of measure	Measure	Elasticity
Neighbourhood	Density (residents/households)	-0.04
Neighbourhood	Employment density	0.00
Neighbourhood	Mixed-use factor	-0.09
Neighbourhood	Intersection density	-0.12
Neighbourhood	% intersections with 4 branches	-0.12
Neighbourhood	Distance to closest transit stop	-0.05
Regional	Accessibility to jobs by car	-0.20
Regional	Accessibility to jobs by transit	-0.05
Regional	Distance to downtown	-0.22
Regional	Distance to high order transit	-0.14 to -0.22

Source: Ewing and Cervero (2010)

4) Identify measures and their impacts

- Type of transit measures are extremely dependent on the type of neighbourhood
- Focus on street grid connectivity and accessibility, rather than just the coverage of active transportation infrastructure. Well-connected street grids are also beneficial for transit use (often designed to minimize through-traffic)
- Existing neighbourhoods are difficult to intervene (high cost for little marginal gain). That said, more potential in areas that have good underlying regional factors (access to jobs, etc.) and in newly built neighbourhoods

Combined Estimated Effect of Measures on VKT and GHG Emissions

Measure	VKT var. per capita – Suburb in large region	VKT var. per capita – Suburb in medium-sized city
Active transport and street connectivity	-1.2%	-1.2%
Transit	-0.8%	+0.2%
Land use (density, mixed-use)	-2.7%	-3.3%
Total	**-4.7%**	**-4.3%**

Conclusion

- Few measures individually are very efficient at reducing VKT and GHG emissions, especially in an existing neighbourhood
- Reducing VKT and GHG emissions in an existing neighbourhood requires a number of measures (land use, active transport, street grid, transit services, etc.)
- The most effective measures depend on a neighbourhood’s unique context (location, constraints and opportunities)
- Implementing measures in an existing neighbourhood is very difficult (time, cost, feasibility, demand, etc.). This is especially the case in neighbourhoods developed without considering how it will change over time
- Method can be applicable to new developments
- Regional planning is essential to reduce GHG emissions and VKT

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