Quick Analysis Technique to Estimate GHG Emissions Based on the Built Form and Street Grid Connectivity
Author

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Presentation outline

→ Introduction
→ Link between the urban form and travel greenhouse gas emissions (GHG)
→ Technique for estimating GHG emissions based on travel activity and the effectiveness of different measures
→ Conclusion
Definitions

→ Alternative transport modes: other modes than driving alone which includes walking, cycling, transit and carpooling.

→ GHG emissions: Greenhouse gas emissions into the atmosphere during a certain period (in CO2 equivalents)

→ Vehicle-kilometres travelled (VKT): Total vehicular kilometres driven using a private vehicle by a study areas residents or other users.
Study problem

→ Identify efficient solutions that reduce GHG emissions by promoting alternative transport modes in a neighbourhood

- Efficiency = measurable

- The impact of different is then assessed based on GHG emissions
GHG emissions and transport in Canada

- Total GHG emissions in Canada (2012): 699 Mt CO2 equiv. (IPCC) - 20.3 tons/person
- Transport represents 28% of total emissions in Canada (43.5% in Quebec). 68% of this total is due to road transport (76% in Quebec).
- Transport emissions have increased by 33% between 1990 and 2012 (37% for road transportation)

Source: Canada National Inventory Report - 2012 (Environment Canada, 2014)
GHG emission and road transport

Main factors driving road transport GHG emissions:

- Energy efficiency | emissions by distance travelled (vehicle or fuel)
- Travel conditions and driver behaviour (e.g. higher emissions in congested areas or at high speeds)
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- Distance travelled
Factors influencing travel distances

- Modal shares (walking, cycling, carpooling, transit, etc.)
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- Length of travel by car
Factors influencing travel distances

- Modal shares (walking, cycling, carpooling, transit, etc.)
- Length of travel by car
- Trips not taken or alternatives to travel
Factors influencing travel distances

→ Large variation between regions
→ Daily vehicle-kilometres travelled (VKT) per capita in select metropolitan areas in Canada.

Source: TAC (2010)
Factors influencing travel distances

- Regional and location factors have a large influence
- Median Commuting Distance by Place of Residence

Source: Statistics Canada (2006)
## Factors influencing travel distances

<table>
<thead>
<tr>
<th>Regional Design</th>
<th>Neighbourhood Design</th>
<th>Individual</th>
</tr>
</thead>
</table>
| -Location of neighbourhood 
-Regional structure 
-Structure of transport networks 
-Accessibility to jobs and retail | -Density 
-Mixed uses 
-Street Grid (connectivity) 
-Proximity to local services and shops 
-Transit (proximity and quality of service) 
-Presence of pedestrian and cycling infrastructure | -Age 
-Sex 
-Auto-selection of households 
-Occupation 
-Revenue 
-Access to a vehicle |

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| -Motive 
-Time of day 
-Constraints 
-Trip chaining 
-Trip frequency |
Factors influencing travel distances

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Actions/tools available at the neighbourhood level
General methodology to assess the effectiveness of measures on GHG emissions

**Four Steps:**

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 alternatives (scenarios) on total VKT travelled
4. Identify and implement measures
Establishing baseline GHG emissions and total VKT

→ Estimation based on origin-destination survey results

Car-driver itineraries for a suburban neighbourhood in the Montreal area during a typical workday (19.0 km per capita per day)
Identifying opportunities and constraints

- **Two residential neighbourhoods were selected**
  - One neighbourhood in suburban Montreal (19.0 km per day per resident)
  - Second neighbourhood in suburban Sherbrooke (29.1 km per day per resident)
Identifying opportunities and constraints

→ Urban Form

Champfleury (Laval)  Mi-Vallon (Sherbrooke)
Identifying opportunities and constraints

Street Connectivity. Lack of connectivity concentrates traffic on major streets.

Champfleury (Laval)  Mi-Vallon (Sherbrooke)
Identifying opportunities and constraints

→ Street Grid

- Important influence on walking and cycling (shorter travel distances, improved accessibility), on transit (direct routes and shorter access) and car travel (shorter distance)

Orthogonal street grid

Central Area

Grid with dead-ends

Suburban Street Grid
Identifying opportunities and constraints

**Street Grid**
- Important influence on walking and cycling (shorter travel distances, improved accessibility), on transit (direct routes and shorter access) and car travel (shorter distance)

**Orthogonal street grid**
- 4.8 intersections/km

**Grid with dead-ends**
- 3.7 intersections/km
Identifying opportunities and constraints

Walking and cycling facilities

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

0.08 street/sidewalk ratio
Identifying opportunities and constraints

- Location of local shops and services: segregated from residences

Champfleury (Laval)  Mi-Vallon (Sherbrooke)
Identifying opportunities and constraints

→ Mixed-Use and Proximity to Services
  - Greater influence on walking and cycling use than transit use
  - Can also reduce car travel distances by providing closer destinations

Access distances to the closest shops

36% of residents within 800m of a shop

35% of residents within 800m of a shop
Measures to reduce GHG emissions

→ Effectiveness of measures was assessed using travel-distance elasticity from different sources (Ewing & Cervero, 2010; Moving Cooler, 2009, etc.)
→ Based on assessments of built form and travel activity research
→ Elasticity is a measure of the rate of change of one variable vs. another

\[
e = \frac{\Delta Q}{Q} = \frac{\Delta Q}{\Delta P} \times \frac{P}{Q}
\]
Measures to reduce GHG emissions

- Possibility to reduce VKT. Low individual effect, but can be important when combined

Source: Ewing and Cervero (2010)
Measures to reduce car travel distances

→ Car-travel distance elasticity

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<td>Employment density</td>
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<td>Mixed-use factor</td>
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Source: Ewing et Cervero (2010)
## Measures to reduce car travel distances

**Car-travel distance elasticity**

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Source: Ewing et Cervero (2010)
Measures to reduce car travel distances

- Street grids: High potential, but little possibility for intervention in an existing area

**Orthogonal street grid**
- 4.8 intersections/km (+30% or 4% less VKT vs. dead-ends)
- 63% 4 way intersections

**Grid with dead-ends**
- 4.7 intersections/km
- 12% 4 way intersections
Measures to reduce car travel distances

→ Car-travel distance elasticity

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Source: Ewing et Cervero (2010)
Impact of scenarios

- Large array of measures implemented at the neighbourhood level (transit, land use, walking, street grid) could reduce vkt per person by 4% to 5% per capita
- More important VKT/GHG emissions reductions could be expected if there were fewer constraints

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<th>VKT var. per capita – Suburb in medium-sized city</th>
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<tr>
<td>Active transport and connectivity</td>
<td>-1.2%</td>
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<tr>
<td>Transit</td>
<td>-0.8%</td>
<td>+0.2%</td>
</tr>
<tr>
<td>Land use (density, mixed-use)</td>
<td>-2.7%</td>
<td>-3.3%</td>
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<tr>
<td>Total</td>
<td>-4.7%</td>
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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 reducing GHG emissions and VKT.
References

→ Ewing, Reid et al. (2007). Growing Cooler : The Evidence on Urban Development and Climate Change, Urban Land Institute, 158 pages.
Questions?

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