Microsimulating Truck Emission and Population Exposure

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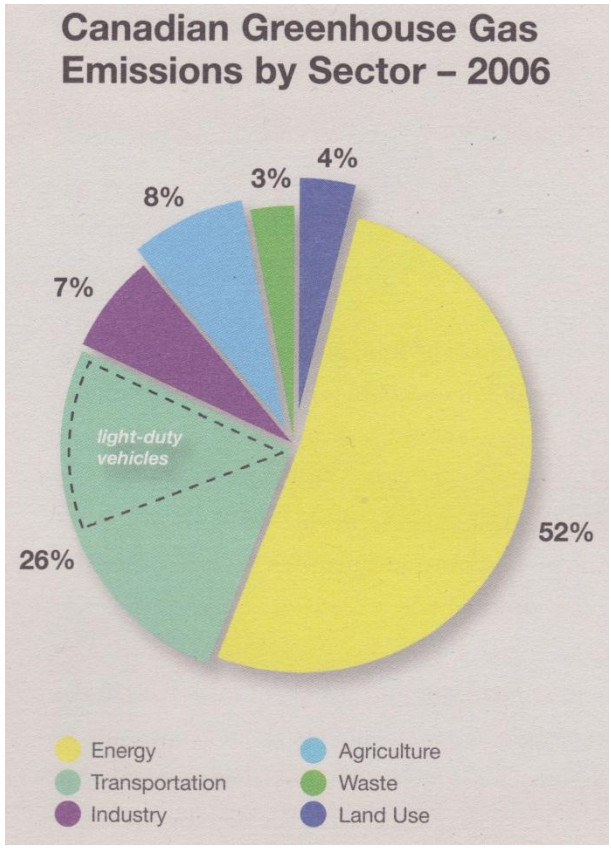
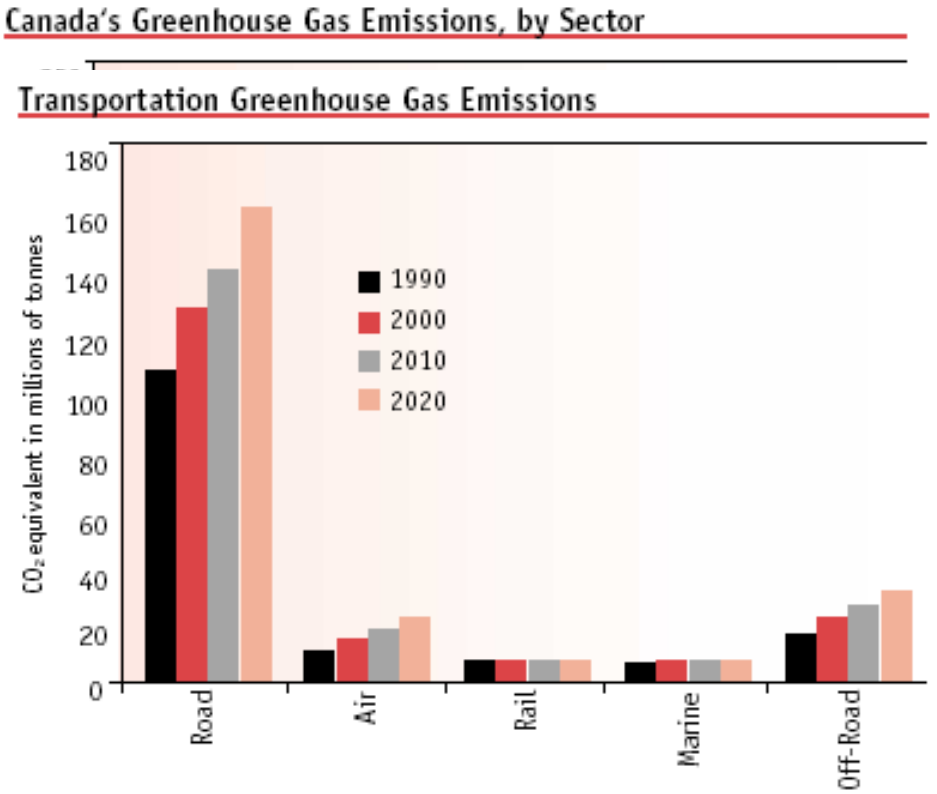
Outline

- Emissions in Canada
- Project Overview
- Study Network
- Building the Base Case
- Scenario Analysis
- Conclusions

Overview



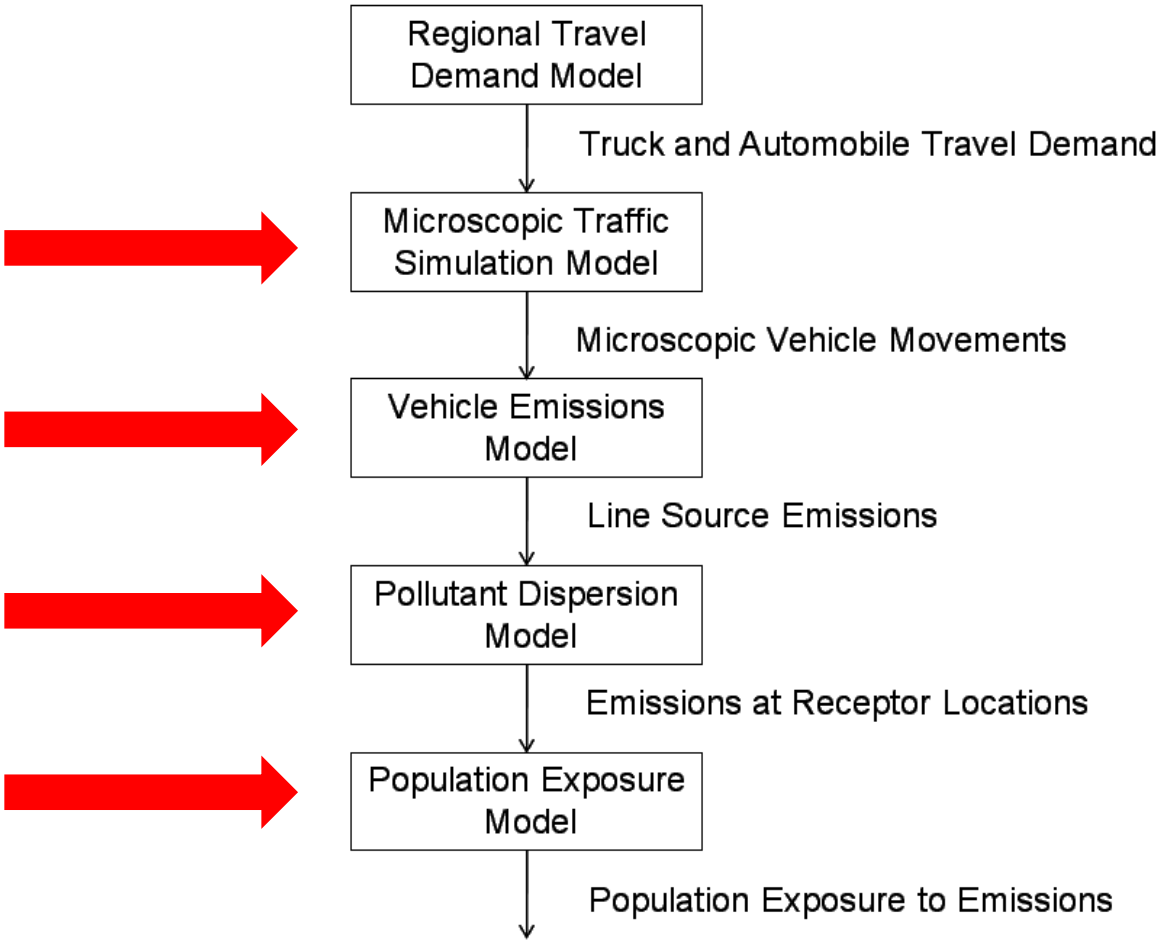
Source: Environment Canada, 2006



Source: TC 2004

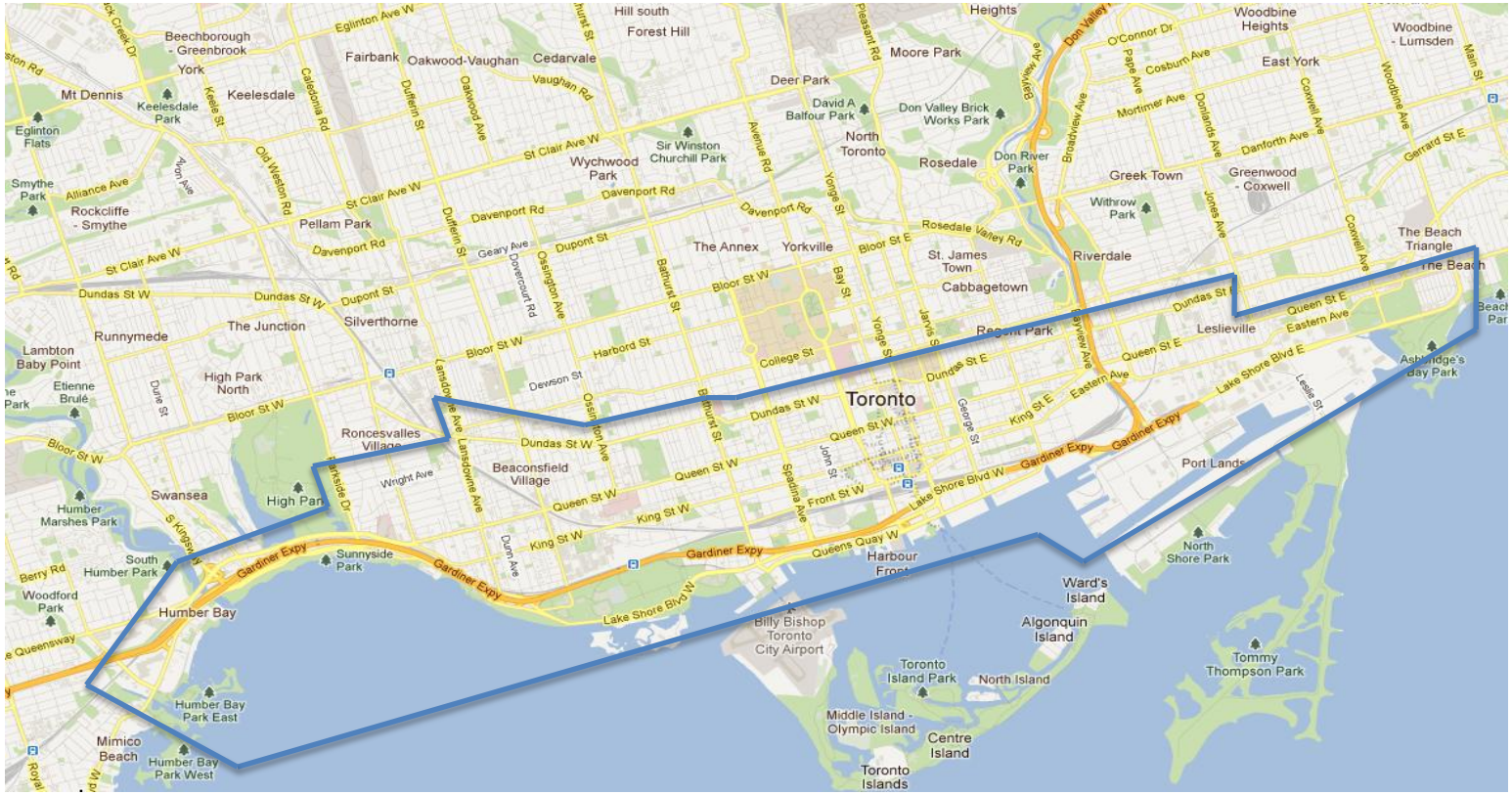
Environment Canada, GHG Inventory, 2008

Project Overview



Study Network

Microsimulation model needs demand inputs (light, medium, heavy trucks and passenger vehicles)

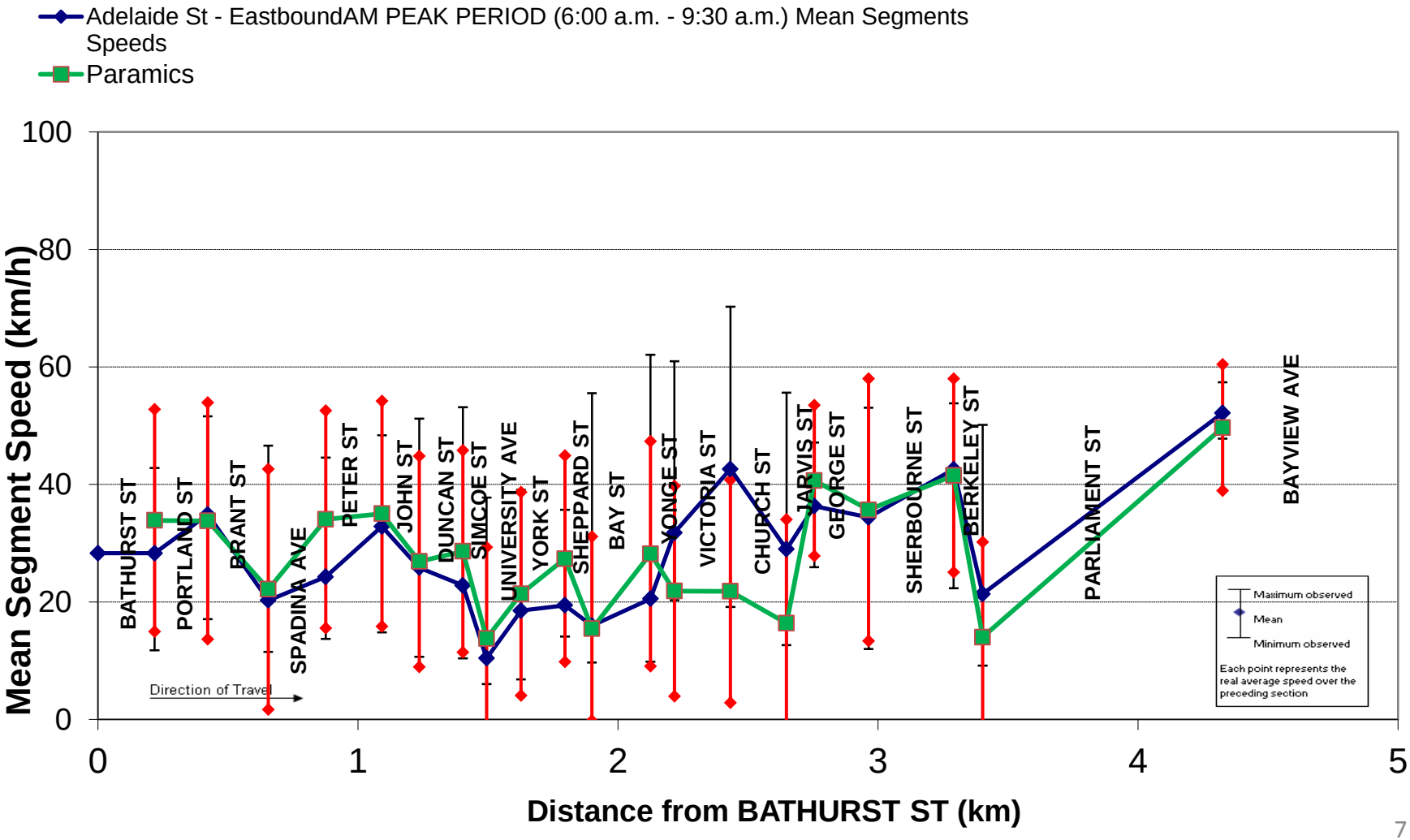


Model Calibration

Model calibrated to reflect

- Road counts
- Loop detector speeds (City of Toronto)
- Truck GPS speeds (Turnpike Global Technologies (TGT))
- Probe vehicle speed (MTO travel time report)

Adelaide- EB


Adelaide St - EastboundAM PEAK PERIOD (6:00 a.m. - 9:30 a.m.) Mean Segments Speeds
Paramics
Mean Segment Speed (km/h)
100
80
60
40
20
0
0
1
2
3
4
5
Distance from BATHURST ST (km)
BATHURST ST
PORTLAND ST
BRANT ST
SPADINA AVE
PETER ST
JOHN ST
DUNCAN ST
SIMCOE ST
UNIVERSITY AVE
YORK ST
SHEPPARD ST
BAY ST
YONGE ST
VICTORIA ST
CHURCH ST
JARVIS ST
GEORGE ST
SHERBOURNE ST
BERKELEY ST
PARLIAMENT ST
BAYVIEW AVE
Direction of Travel
Maximum observed
Mean
Minimum observed
Each point represents the real average speed over the preceding section

Calibrated Network

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Emission Modelling

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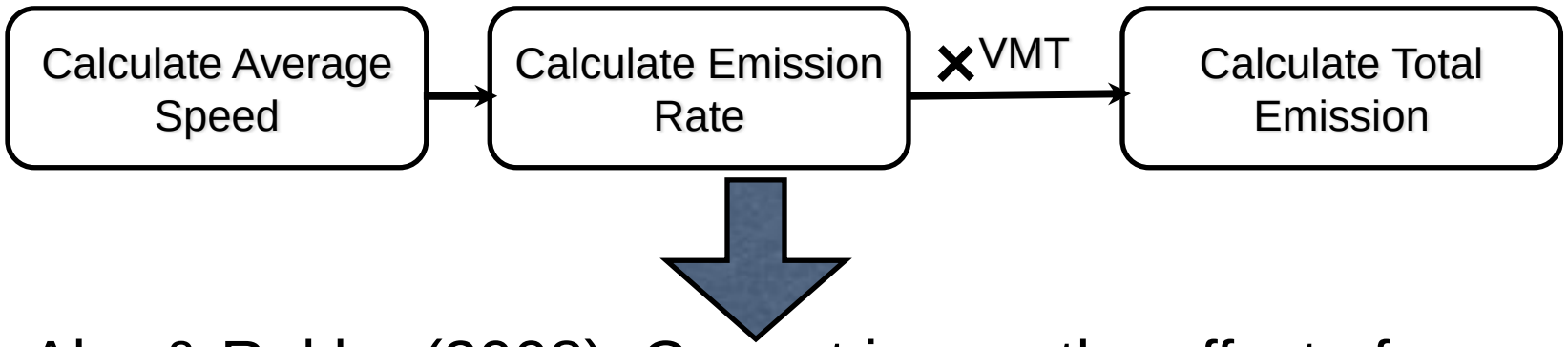
Average Speed vs. Micro-emission Models



Ahn & Rakha (2008): Cannot ignore the effect of instantaneous speed

Microscopic emission modeling

Microscopic emission models

- Second-by-second emission estimation

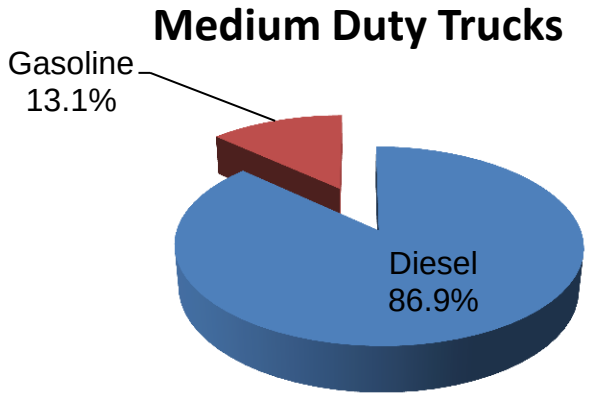
- Most useful in microenvironments, such as busy streets or intersections where vehicle idling, acceleration, and deceleration may have significant impacts on drive cycle emissions

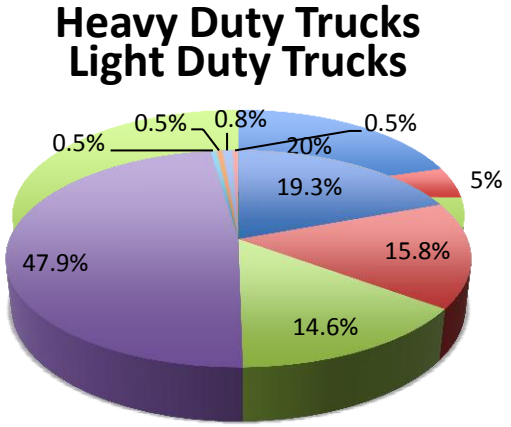
- Examples:
  - CMEM, University of California Riverside
  - VT-Micro, Virginia Tech
  - MOVES, EPA

CMEM Model

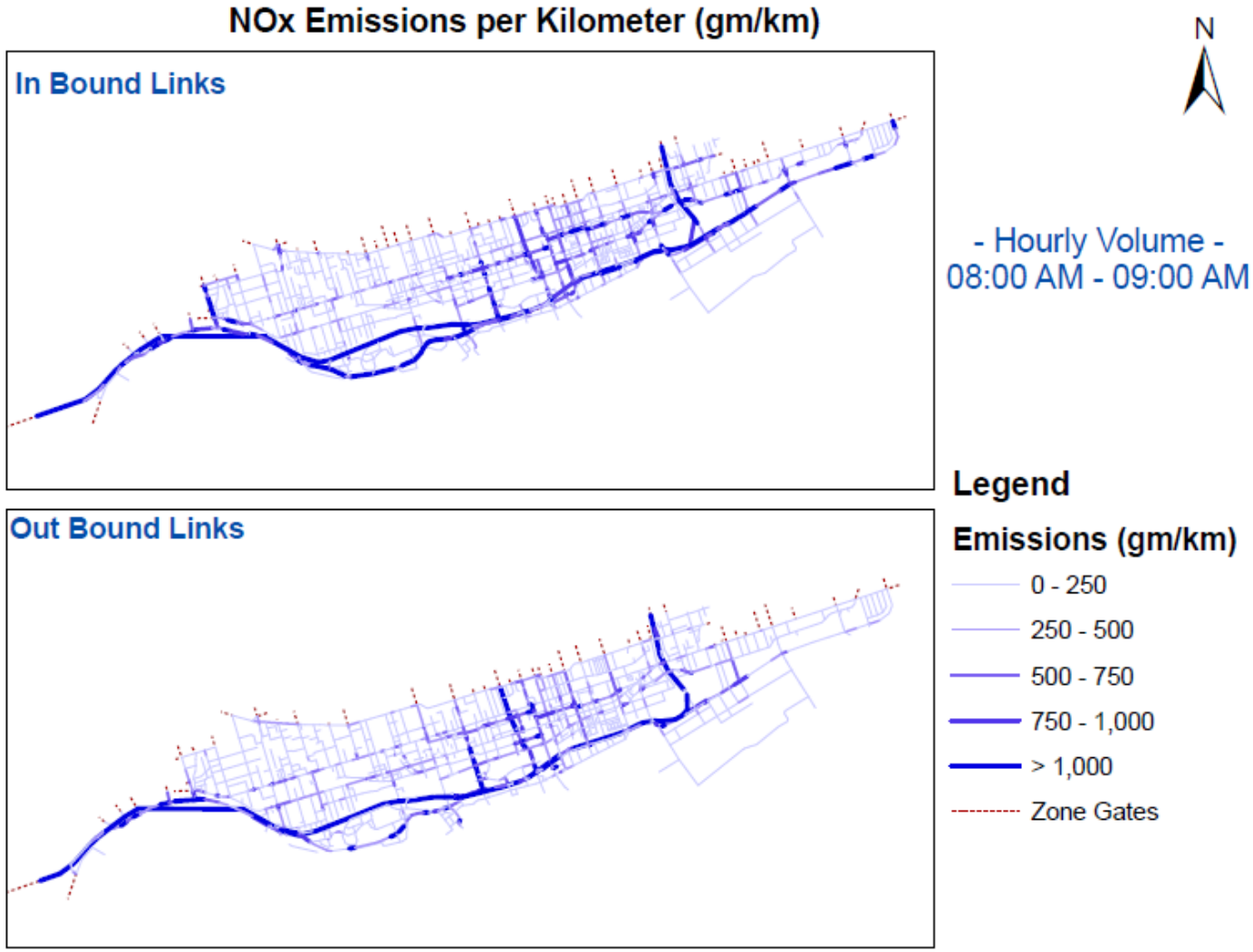
Requires detailed makeup of the vehicle fleet

- Canadian vehicle survey 2009
- Vehicle sales reports
- Consultant's reports
- CMEM user manual





Emission Results



Dispersion Modelling

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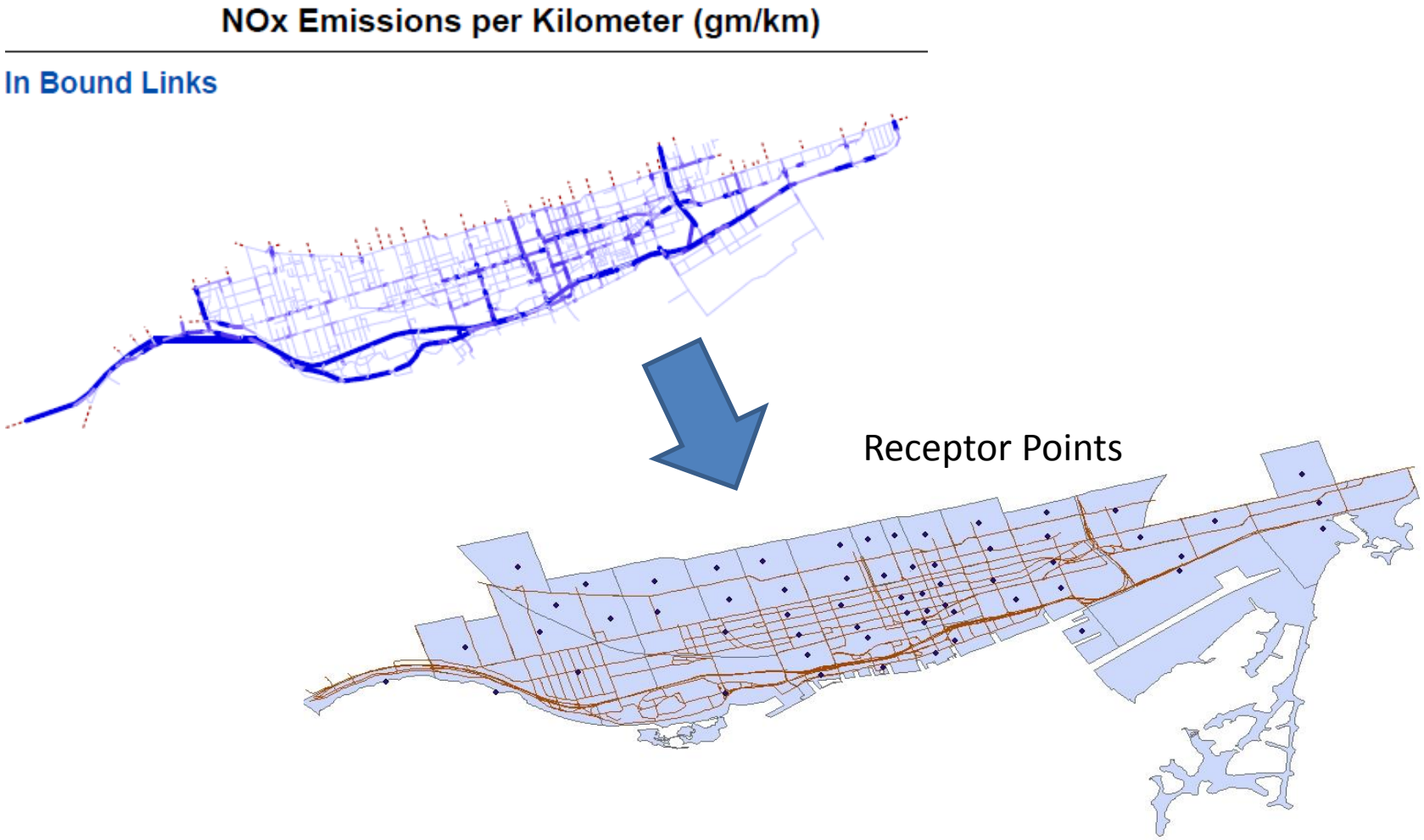
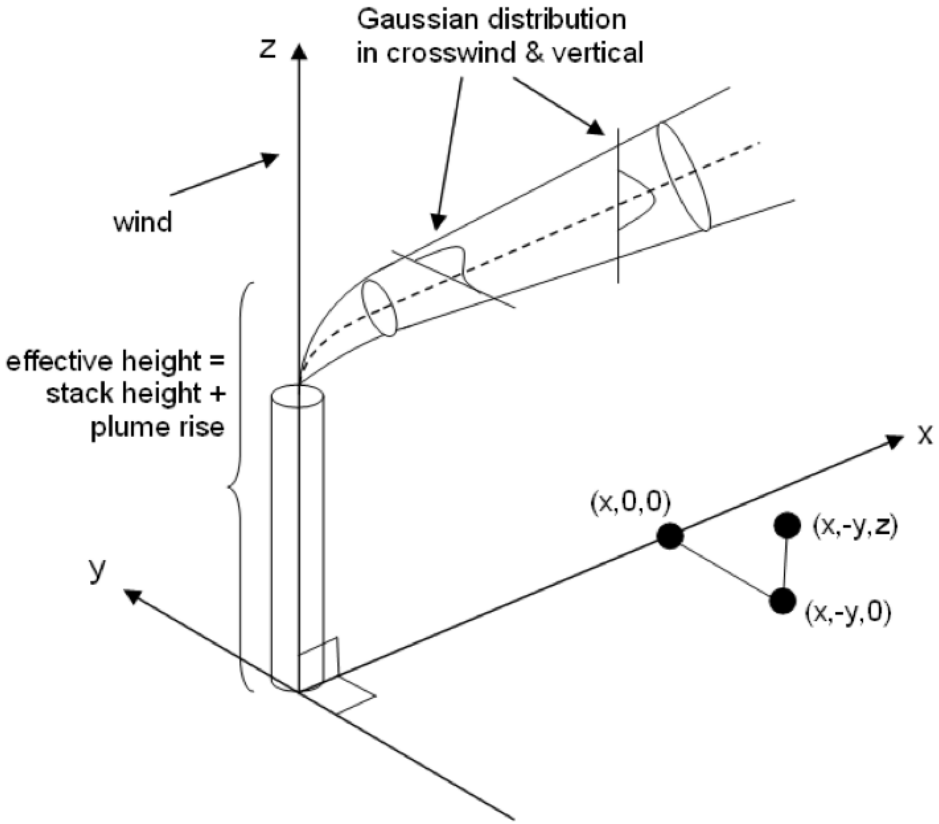
Dispersion Modelling

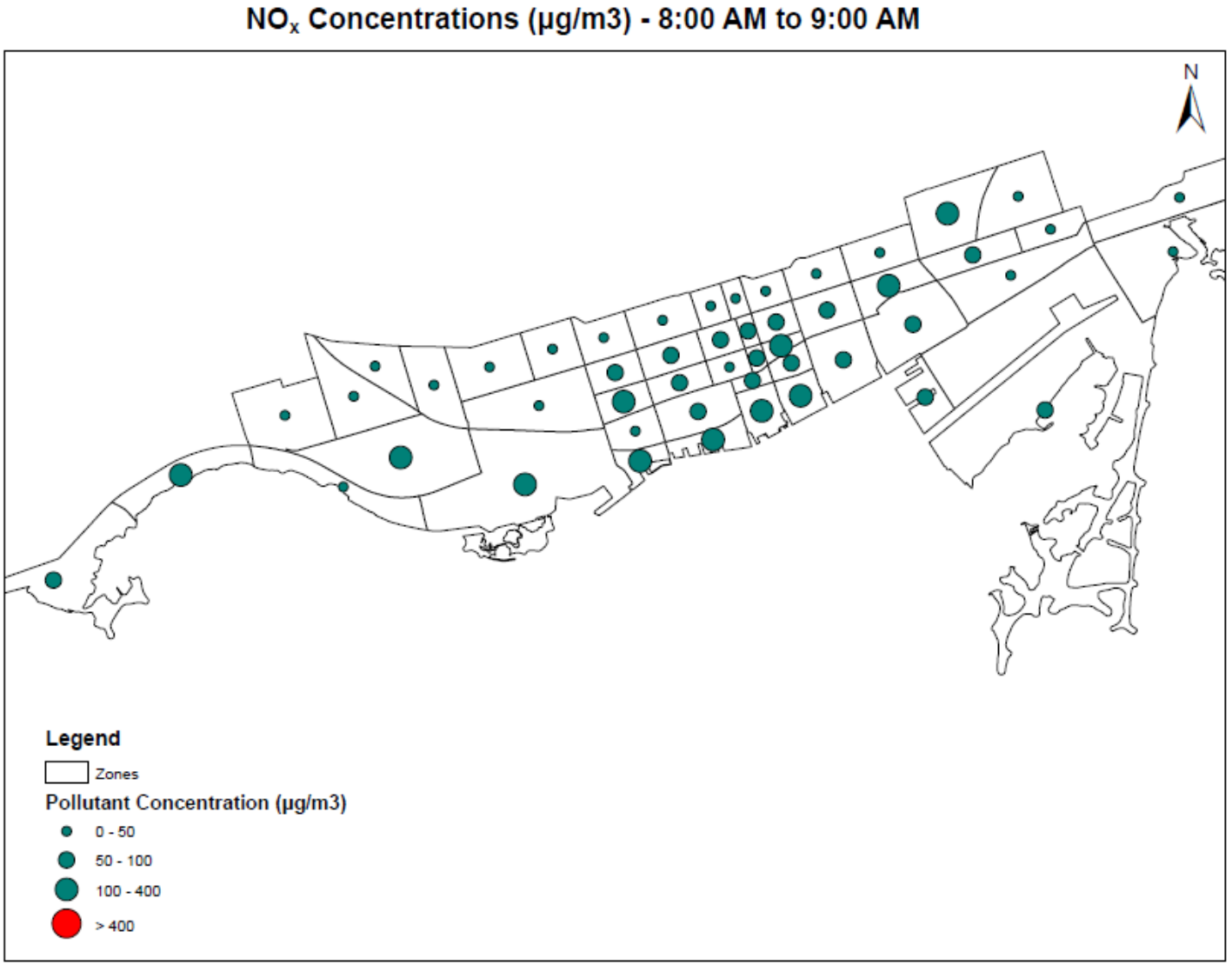


Gaussian Plume Models



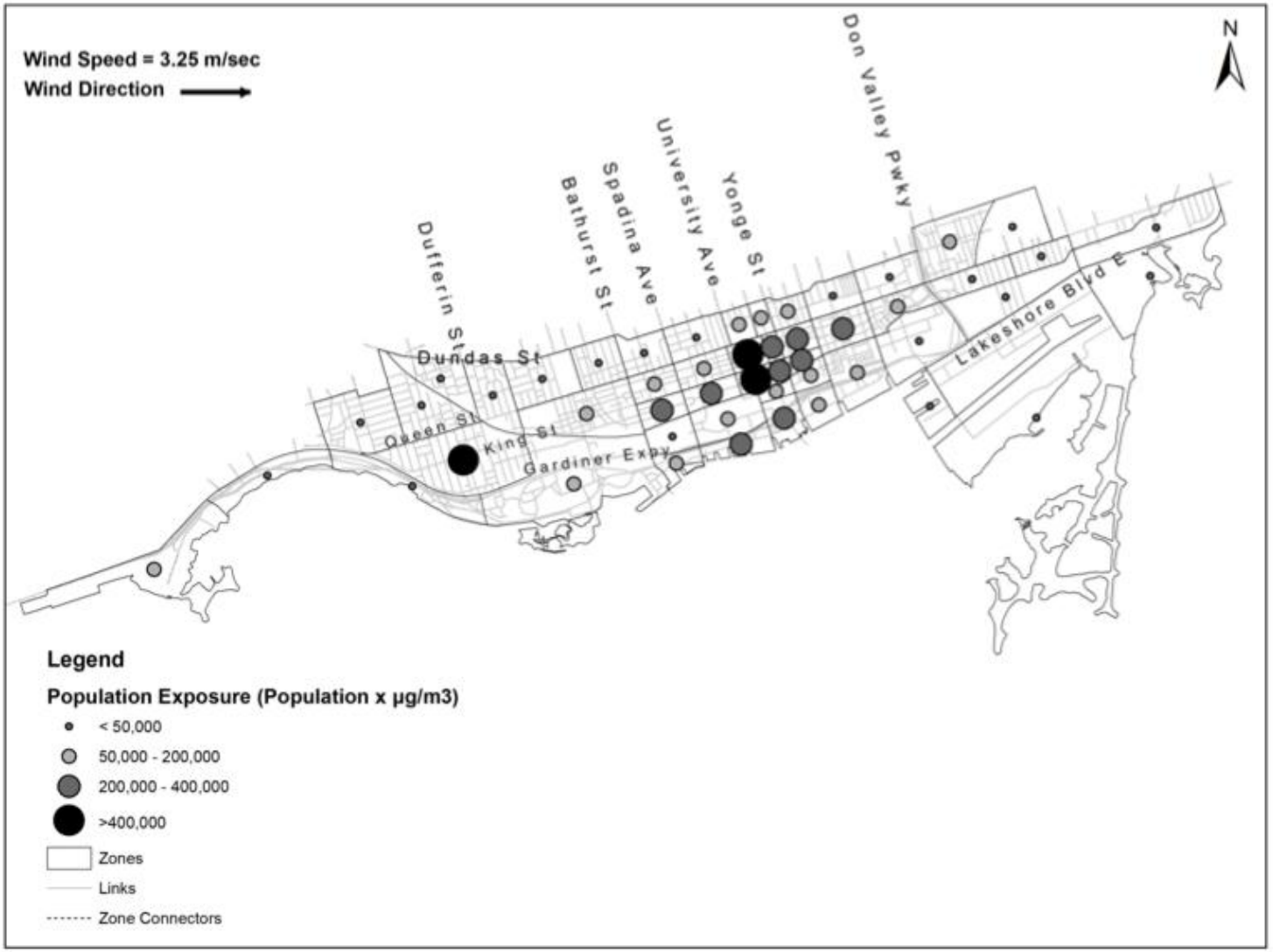
Hatzopoulou, 2008

Dispersion Results



Population Exposure

Population Exposure



Scenario Analysis

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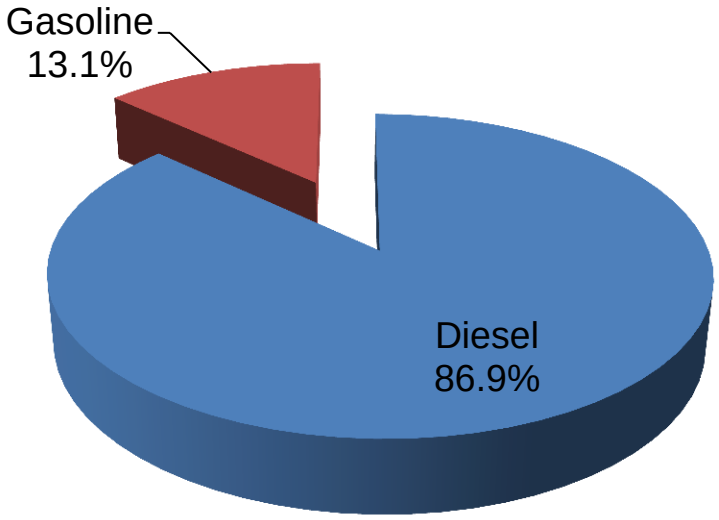
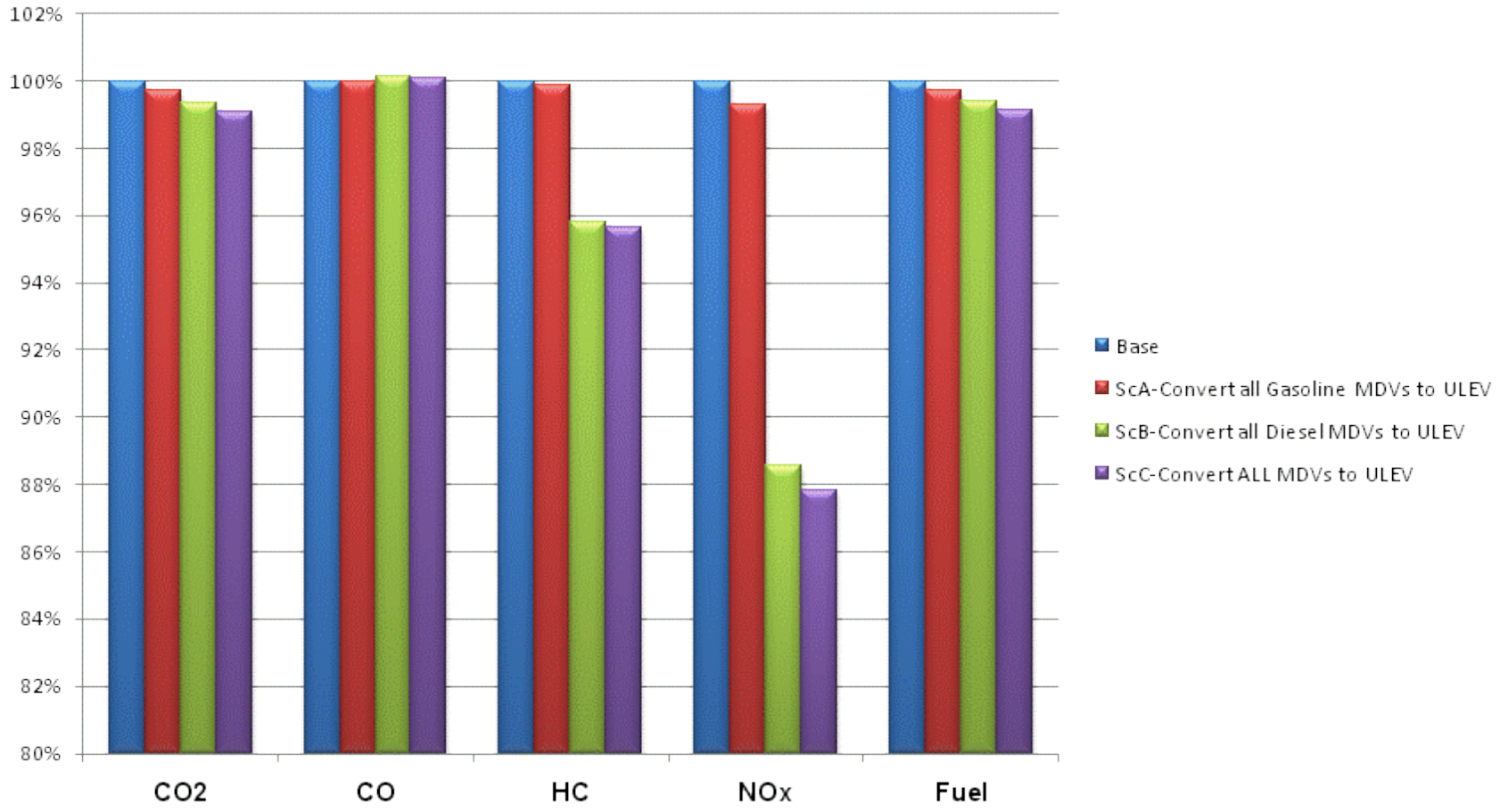
Scenario Analysis

CMEM categorizes Medium Duty trucks based on their engine type: Gasoline vs. Diesel

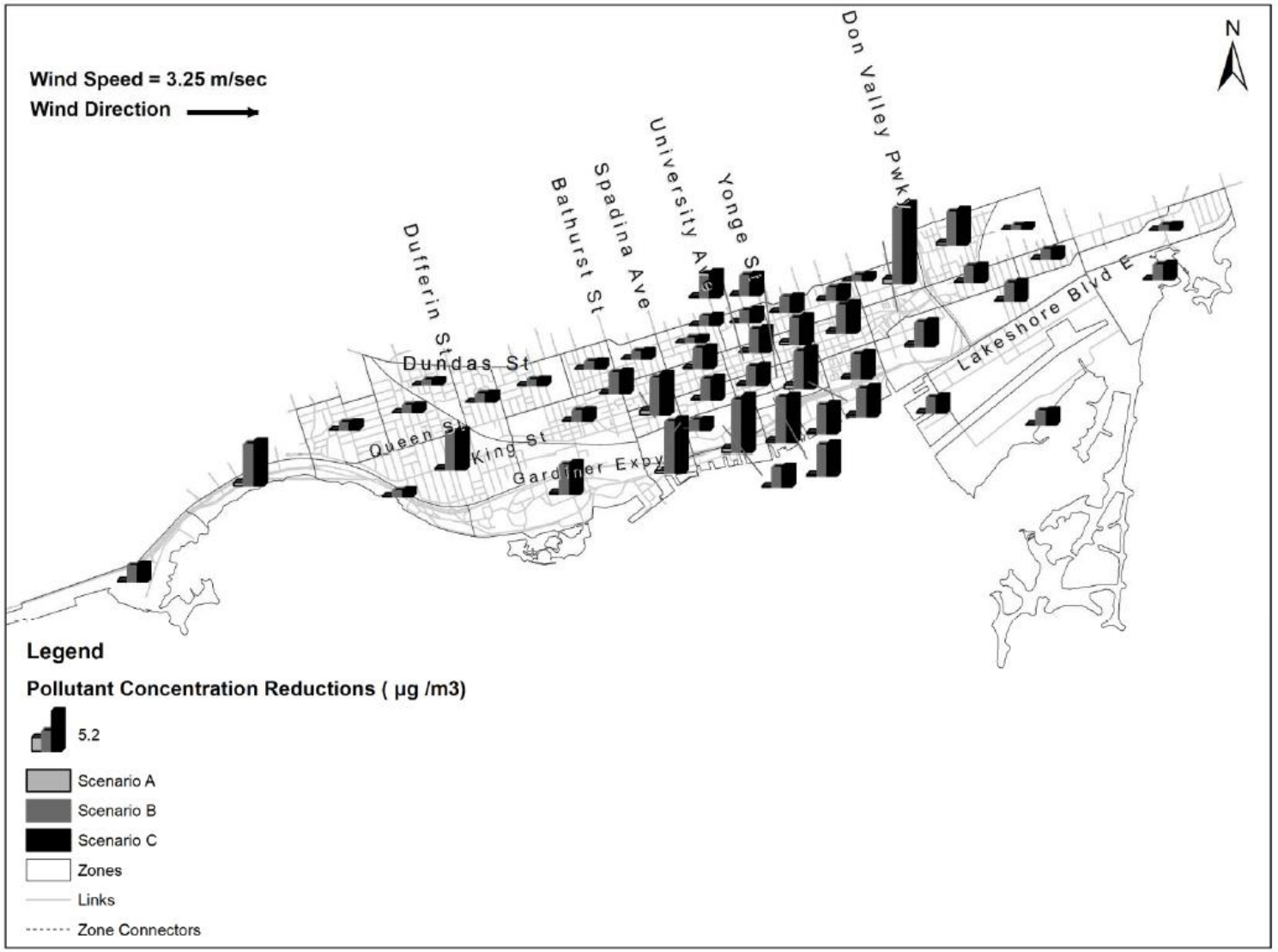


Source: CVS Report

Scenario Comparison



Scenario Comparison



Conclusions

- ✓ Emissions of HC, CO, CO_2 and NO_x are highest on the high capacity roadways;

- ✓ Emission factors (grams/VKT) vary over each roadway segment in the network;

- CO, NO_x and HC concentrations at zone centroids are within recommended levels by Environment Canada on a day with typical wind direction and average wind speed;

Conclusions

- ✓ Zones along the freeways experience higher pollutant concentrations;

- ✓ Higher wind speeds will lead to a faster dilution of pollutants;

- A 100% conversion of diesel powered medium duty trucks is estimated to reduce total HC and NO_x emissions by 4% and almost 12%, respectively;

Thank **you!**

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Feb-2012

Limitations and Future Research

- The effect of roadway grade on emissions has been ignored in this research. Data regarding roadway grades would be required to undertake this analysis;

- Emission of particulate matter could not be evaluated using the CMEM modelling software;

- The accuracy of vehicle emissions relies upon accurate acceleration and deceleration profiles within the microscopic traffic simulation model (Ongoing);

- Validation of the emission model for Toronto using real-word emission sensors
  - Hoy and Roorda (2011)
  - Misra and Roorda (Ongoing)

Slides??

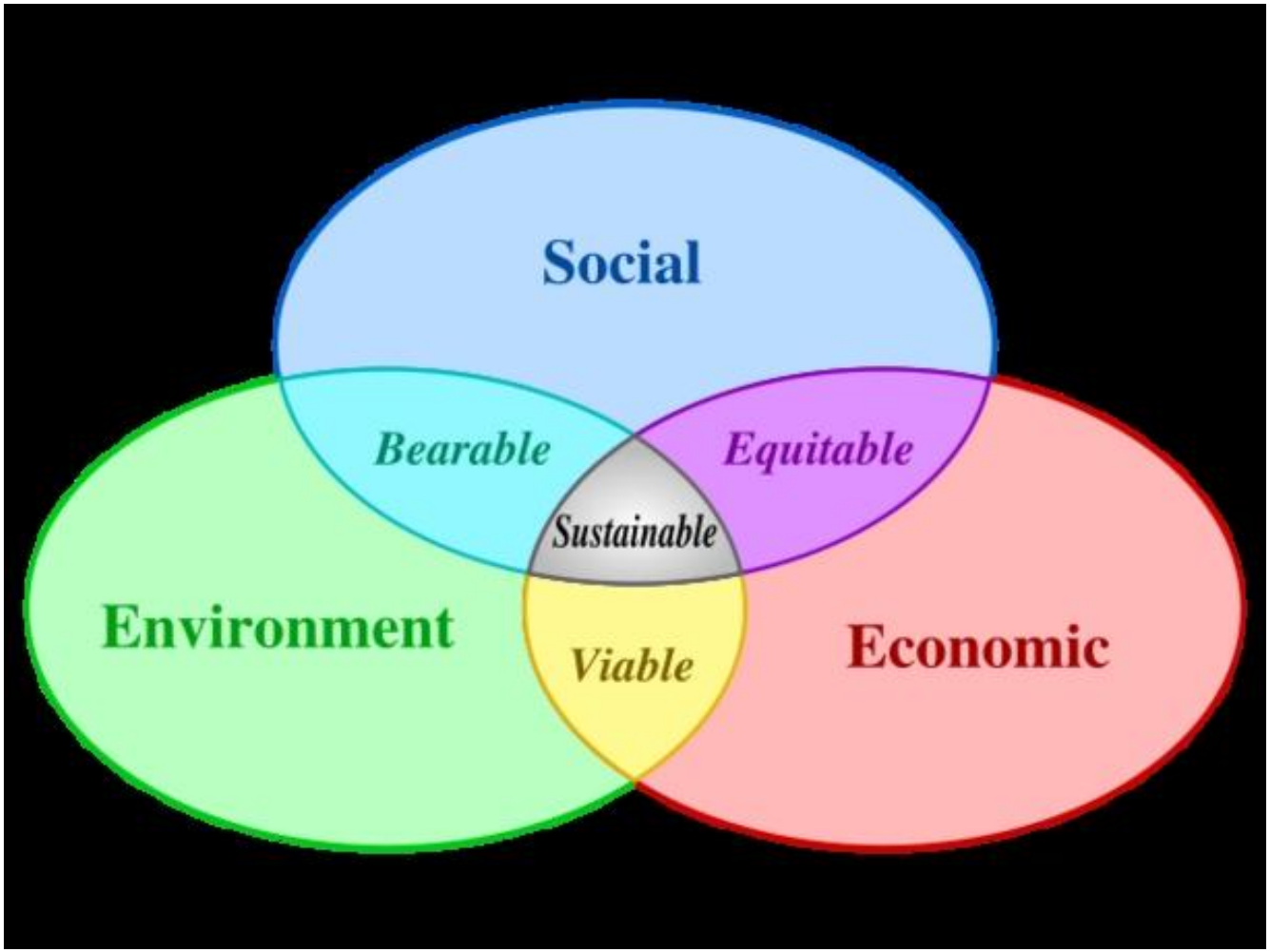
- Show or not show the clip for the simulation?
- In terms of CMEM vs MOVES: Do I need to include a slide justifying why CMEM was chosen?

1. How does this paper contribute to sustainable urban freight transportation? (next slide)
2. Does this paper contain, or lead to, and innovation in urban freight transportation? (the innovation is mostly the integration of different available models)
3. Are there opportunities to apply this approach to other geographic areas? What would be the concerns or issues in doing so? This can be applied to other geographic areas. Points that have to be considered when doing so are:

   a) the need for data sources that are required in developing the model (demand/microsimulation/ fleet distribution/ Meteorological data)

   b) Also in cities like Mexico where the city is kind of surrounded by hills-> the affect of pollution getting trapped or something (inversion)
4. Has this tool or approach been applied in practice? What were the lessons learned?
5. What practical concern does your research address? What are the strengths and weaknesses of your approach or analysis?
6. What elements of your approach are specific to the local political and cultural environment?
7. What additional research would you recommend follow this work? (in the presentation to some extent)
8. Have you had any feedback on your work from other stakeholders, such as the private sector, public sector, and community or social groups? (NO)
9. What does this research teach us about the freight/land use connection, and land use strategies ?????????????

3 Pillars of Sustainability



Types of Dispersion Models

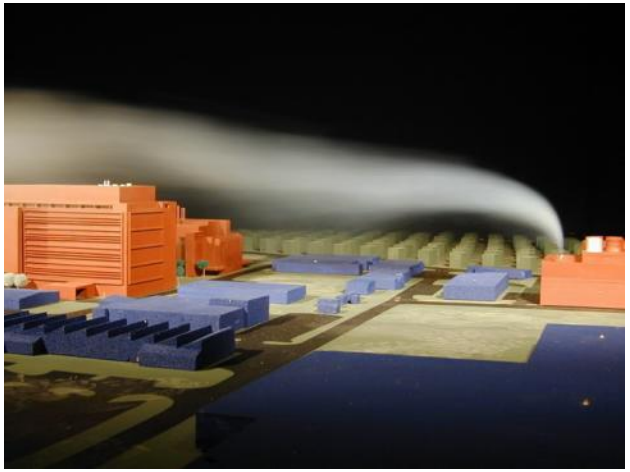
1) Physical Models - Empirical

2) Box Models – Conservation of Mass

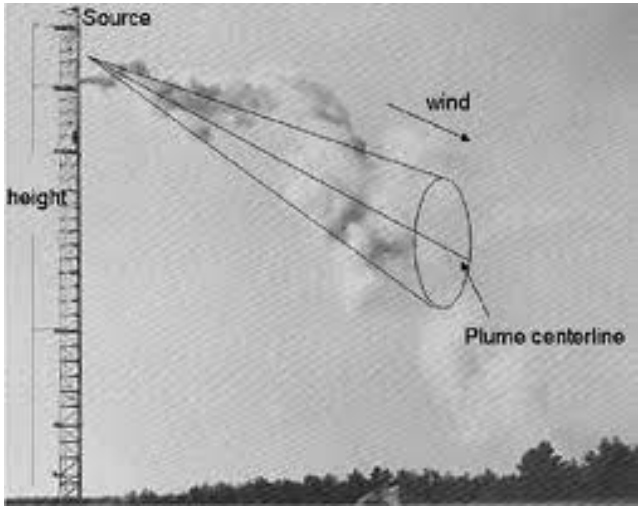
3) Gaussian Models – Gaussian Plume/ Puff models

4) Lagrangian/Eulerian Models – Extension of Box Models

5) Computational Fluid Dynamics Models – Navier-Stokes Equation



Physical Models



Gaussian Models

Holmes, N.S. Morawska, L. 2006